University of Toronto

Calendar 1977-1978

Faculty of Applied Science and Engineering

University of Toronto

Faculty of Applied Science and Engineering

Calendar 1977-1978

University of Toronto Press
1977

Contents

CALENDAR 1977

January

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

February

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28					

March

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

April

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

May

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

June

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

July

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

August

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

September

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

October

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

November

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

December

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

CALENDAR 1978

January

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				

March

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

April

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

May

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

June

S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

July

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

August

S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

September

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

October

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

November

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

December

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

FALL TERM, 1977

August 29 to September 2	Monday Friday	Students who have not received a timetable confirming their pre-registration must register in person in this week.
September 5	Monday	Labour Day. Buildings closed.
September 6	Tuesday	Orientation program for First Year students.
September 7	Wednesday	Lectures and laboratory work commence at 9:00 a.m.
September 23	Friday	Last day for students to add or substitute Fall Term courses (including Fall Term or Full Year courses taken in the Faculty of Arts & Science).
October 10	Monday	Thanksgiving Day. Buildings closed.
October 27	Thursday	Meeting of Faculty Council.
October 28	Friday	Last day for students to drop a Fall Term course without academic penalty (including Fall Term courses taken in the Faculty of Arts and Science.)
November 11	Friday	Last date for withdrawal from the Fall Term without academic penalty.
December 7	Wednesday	Last day of lectures in Fall Term. All term work should be submitted by this date.
December 8 to December 22	Thursday Thursday	Study and examinations in Fall Term courses.
December 25	Sunday	Christmas Day. Buildings closed.

SPRING TERM, 1978

January 1	Sunday	New Year's Day. Buildings closed.
January 3	Tuesday	Lectures and Laboratory work commence at 9:00 a.m.
January 13	Friday	Last day for students to add or substitute Spring Term courses.
		Last day to drop a full year course without academic penalty and without credit.

January 25	Wednesday	Meeting of Faculty Council.
February 13 to	Monday	Reading Week. Lectures and laboratories withdrawn
February 17	Friday	Last day for students to drop a Spring Term course without academic penalty (including Spring Term courses taken in the Faculty of Arts and Science).
March 10	Friday	Last date for students to withdraw from the Spring Term without academic penalty.
March 24	Friday	Good Friday. Buildings closed.
April 12	Wednesday	Last day of lectures in Spring Term. All term work should be submitted by this date.
April 13 to	Thursday	Study and examinations in Spring Term courses.
April 27	Thursday	
May 23	Tuesday	Meeting of Faculty Council.

II

The Faculty of Applied Science and Engineering

ADMINISTRATIVE STAFF

Dean: B. Etkin, B.A.SC., M.A.SC., D.ENG., F.A.I.A.A., F.C.A.S.I., F.R.S.C., P.ENG.
Associate Deans: R. E. Jervis, M.A., PH.D., P.ENG.
W. A. Miller, B.ENG., M.ENG., PH.D.(McG.), P.ENG.
Assistant Dean: M. J. S. Leitch, B.ARCH., F.R.A.I.C., P.ENG.
Assistant Dean and Secretary: J. A. Gow, B.A.SC., P.ENG.
Faculty Registrar: E. Claire Alleyne, B.A., M.A.
Manager of Student Services: Jean K. Madill, B.SC.
Information Systems Manager: B. M. Leathem, B.A.SC., P.ENG.

The Faculty of Applied Science and Engineering in the University of Toronto offers a very wide range of undergraduate and post-graduate studies in engineering. Students may qualify for the Bachelor of Applied Science Degree (B.A.Sc.) in any one of eight programs: Civil Engineering; Geological Engineering and Applied Earth Science; Mechanical Engineering; Industrial Engineering; Engineering Science; Chemical Engineering; Electrical Engineering; Metallurgy and Materials Science. Within these programs there are many electives and options. In the Geological Engineering program, students can specialize in Mineral Exploration, Mineral Engineering or Geotechnical Engineering. In the Engineering Science program, students can in their final two years take one of the options: Aerospace; Chemical; Computer Science; Electrical; Geophysics; Materials Science; Nuclear and Thermal Power; Physics. Thus, an engineering student can specialize in virtually any significant branch of modern technology. Admission standards in the First Year curriculum are common to all programs except Engineering Science. Admission to the latter is restricted to High School graduates with substantially better than minimum qualifications, and the First Year curriculum in that program is more demanding both in level and in pace.

The bulk of the teaching of undergraduate students in engineering is provided by the six departments of the Faculty (which altogether comprise about 180 professors): Civil Engineering, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, Metallurgy and Materials Science. Additionally, undergraduate

teaching is provided by the Institute for Aerospace Studies (an Institute of this Faculty) and the Institute of Biomedical Engineering (an Institute in both this Faculty and the Faculty of Medicine).

The Faculty is most fortunate in being part of a great university, and consequently has available to it the resources of other Divisions, upon which it draws to great advantage. The Departments of Geology, Mathematics, Computer Science, Physics, English, History, Philosophy, and Political Economy, all in the Faculty of Arts and Science, make contributions to the engineering curriculum which greatly enrich it.

Beyond the undergraduate level, the Faculty has a strong commitment to graduate studies and research. Graduate programs leading to the M.Eng., M.A.Sc., and Ph.D. degrees are offered through the School of Graduates Studies by each of the six departments and two institutes previously mentioned. The staff of the Faculty also contributes at the graduate level to the programs of several other centres and institutes in the areas of urban planning, transportation, environmental studies and history of technology. This remarkable pattern of bridges linking the arts, sciences and professions in studies of man, his ideas and his work, lends a distinctive vitality and range to engineering at Toronto.

Since its founding in 1873, the School of Practical Science at the University of Toronto, which became the Faculty of Applied Science and Engineering in 1906, has conferred more than 20,000 degrees and diplomas. The graduates of the Faculty have pursued diverse careers in all fields of engineering throughout Canada and the world: in the resource industries, manufacturing, transportation, communications; in law, finance and health care systems. They are employed by governments from the municipal to the federal level, in private enterprise, both large and small, and throughout our educational system. The Engineering Alumni Association, to which all graduates belong, actively supports the ongoing work of the Faculty and, through representative membership on the Faculty Council, participates in the governance of the Faculty.

The Engineering Society, the undergraduate student association, is the oldest engineering organization of any formal kind in Canada. The Society, through its constituent clubs and the Faculty Athletic Association, co-ordinates a broad program of technical, social and athletic activities for the benefit of the undergraduate students.

The buildings of the Faculty are located on the main campus of the University in a rectangle bounded on the south by College Street, the west by St. George Street, the north by Convocation Hall, and on the east by Taddle Creek Road. The administrative offices are located in the Galbraith Building, 35 St. George Street. Students seeking information about any aspect of study in the Faculty are welcome to inquire here.

UNDERGRADUATE PROGRAMS

The Faculty offers the following programs leading to the degree of Bachelor of Applied Science:

Civil Engineering (Program 1)
Geological Engineering and Applied Earth Science (Program 2)
  Mineral Exploration (Option 2A)

Mineral Engineering (Option 2B)
Geotechnical Engineering (Option 2C)
Mechanical Engineering (Program 3)
Industrial Engineering (Program 4)
Engineering Science (Program 5)
Aerospace (Option 5a)
Chemical (Option 5c)
Computer Science (Option 5cs)
Electrical (Option 5e)
Geophysics (Option 5g)
Materials Science (Option 5m)
Nuclear and Thermal Power (Option 5nt)
Physics (option 5p)
Chemical Engineering (Program 6)
Electrical Engineering (Program 7)
Metallurgy and Materials Science (Program 8)

The curricula of the various programs are set out in detail in Section XI. The regulations for standing and promotion are given in Section X.

PART-TIME STUDY – WOODSWORTH COLLEGE

The first two years of all engineering programs except Engineering Science are also offered through Woodsworth College for students interested in part-time study. The First Year program is available in both day-time and evenings, the Second Year in day-time only. As there is no provision for part-time study in engineering beyond the Second Year, students wishing to complete their studies for the degree must enter into full-time study in the regular courses in the Faculty of Applied Science and Engineering.

Information regarding Part-Time Study may be obtained from the Degree Courses Section, Woodsworth College, 119 St. George Street, University of Toronto, Toronto M5S 1A1.

GRADUATE STUDY AND RESEARCH

Facilities available in the Departments of the Faculty for postgraduate study and research leading to the degrees of Master of Engineering (M.Eng), Master of Applied Science (M.A.Sc.), and Doctor of Philosophy (Ph.D.) are described in Section III. For further information see the Calendar of the School of Graduate Studies.

SPECIAL STUDENTS

Persons desiring to enroll as Special Students (not proceeding to the degree) should consult the Secretary of the Faculty regarding admission requirements and the procedure for application.

INTERIM HIGH SCHOOL ASSISTANTS' CERTIFICATE TYPE A

Graduates of engineering programs may be admitted to Type A certificate courses at the Faculty of Education, University of Toronto, if they submit official transcripts which indicate that they have sufficient academic credits.

Graduates of engineering programs who lack sufficient academic credits for admission to Type A courses at the Faculty of Education may be eligible for admission to the Type B course and later for endorsement of the Type B certificate.

Inquiries regarding admission to the Type B course should be addressed to the Registrar, Faculty of Education, University of Toronto. Inquiries regarding endorsement of Type B certificates or admission to Type A certificate courses should be addressed to the Director, Committee on Advanced Standing, Faculty of Education, University of Toronto.

ASSOCIATIONS OF PROFESSIONAL ENGINEERS

Graduation from the Faculty of Applied Science and Engineering leads to registration as a Professional Engineer in the various provincial associations of Professional Engineers, in accordance with their individual policies.

SUMMARY OF STUDENTS IN ATTENDANCE – *Session 1976–77*

PROGRAM		1	2	3	4	5	6	7	8	TOTAL
Year	I	95	20	107	43	153	99	103	18	638
	II	107	36	114	66	69	102	132	20	646
	III	110	30	96	66	76	98	111	8	595
	IV	92	21	82	64	66	69	101	14	509
TOTAL										2388

III

Departments and Divisions of the Faculty

DIVISION OF FIRST YEAR STUDIES

Chairman:
W.A. Miller, B.ENG., M.ENG., PH.D., P.ENG.

In his first year of studies, an engineering student must establish a strong foundation in the basic disciplines which underlie the whole field of Engineering. The First Year program has been designed to this end, providing for courses in mathematics and in the physical, chemical and engineering sciences. In addition, the student is given an opportunity to broaden his education and outlook through the Non-Technical Electives. There are two First Year curricula: Engineering, the standard curriculum; and Engineering Science, the enriched curriculum.

The Engineering Science curriculum is designed for students who intend to continue in one of the following options in Third Year: Aerospace, Chemical, Computer Science, Electrical, Geophysics, Materials Science, Nuclear and Thermal Power, and Physics. The curriculum is demanding and admission to First Year Engineering Science is granted only to those students with better than average ability in mathematics and the sciences. Students undertaking this curriculum must maintain satisfactory term averages in their first year work in order to pursue the Engineering Science program in their second year. Transfers from Engineering Science to other programs are permitted, subject to the Academic Regulations (Section IX), for students in good standing at the end of the first term or the first year.

The Engineering curriculum is designed for students who intend to continue in one of the following programs in Second Year: Civil Engineering, Geological Engineering and Applied Earth Science, Mechanical Engineering, Industrial Engineering, Chemical Engineering, Electrical Engineering, and Metallurgy and Materials Science. Students must elect one of these programs on entering the First Year, and this election guarantees a place in that program in Second and subsequent years, subject to maintenance of satisfactory standing. Subject to the availability of places, a student who successfully completes the First Year in one of the above programs may request to transfer to any other of these

programs. Because of the special nature of the Engineering Science curriculum, transfers from these programs to Engineering Science are not possible except in extraordinary cases.

Students wishing to transfer to a different program at the end of First Year should make application to the Faculty Office not later than June 15.

For details of the First Year curricula, refer to Section XI of this calendar.

DEPARTMENT OF CIVIL ENGINEERING

Professor and Chairman of the Department:
G. W. Heinke, B.A.SC., M.A.SC., PH.D.(McM.), P.ENG.

Associate Professor and Associate Chairman of the Department:
G. T. Will, B.A.SC., M.A.SC., P.ENG.

Professors:
F. A. DeLory, B.ENG.(McG.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.), P.ENG.
J. Ganczarczyk, M.SC., D.SC.(GLIWICE), D.SC.(WARSAW), F.R.S.H., P.ENG.
M. W. Huggins, B.A.SC., M.A.SC., F.E.I.C., F.A.S.C.E., P.ENG. (*part time*)
P. H. Jones, B.A.SC., M.S.(NORTHWEST.), PH.D.(NORTHWEST.), P.ENG.
T. C. Kenney, B.ENG.(McG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), P.ENG.
R. H. Mills, B.SC.(WITWATERSRAND), F.I.C.E.
J. Schwaighofer, DIP.ING.(GRAZ), M.S.(PENN.ST.), PH.D.(PENN.ST.), DR.TECH.(GRAZ), P.ENG.
R. M. Soberman, B.SC.(DAL.), PH.D.(M.I.T.), P.ENG. (*part time*)
S. M. Uzumeri, B.A.SC., M.A.SC., P.ENG.

Associate Professors:
J. D. Barber, B.A.SC., M.A.SC., P.ENG.
P. C. Birkemoe, B.SC.E., M.S.C.E.(PURDUE), PH.D.(ILL.), P.ENG.
G. S. Birrell, M.S.(ILL.)
M. P. Collins, B.E.(CANTERBURY), PH.D.(N.S.W.), P.ENG.
R. A. Collins, B.A.SC., M.S.(ILL.), PH.D.(ILL.), P.ENG.
A. C. Davidson, B.SC., C.E., B.SC., E.E.(MAN.), M.A.SC., F.E.I.C., P.ENG.
M. M. Davis, B.SC.,(QU.), M.SC.(PURDUE), P.ENG.
E. Hauer, B.SC., M.SC.(TECHNION), PH.D.(CALIF.), P.ENG.
B. J. Haynes, B.A.SC., P.ENG.
J. G. Henry, B.SC.(QU.), M.S.E.(PRINCETON), PH.D., P.ENG.
V. F. Hurdle, B.S.(CALIF.), M.ENG.(CALIF.), PH.D.(CALIF.), P.E.(CALIF.).
H. L. Macklin, B.A.SC., F.E.I.C., P.ENG. (*part time*)
E. I. Robinsky, B.A.(BEIRUT), B.SC.,(BEIRUT), M.S.(HARVARD), PH.D., P.ENG. (*part time*)
K. A. Selby, B.A.SC., M.B.A., PH.D.(ILL.), P.ENG.

G. N. Steuart, B.SC.(SASK.), M.SC.(CALIF.), PH.D.(CALIF.), P.ENG. (*on leave*)
J. Timusk, B.A.SC., M.A.SC., PH.D.(LOND.), P.ENG. (*on leave*)
P. M. Wright, B.E., M.SC.(SASK.), PH.D.(COLO.), P.ENG.

Assistant Professors:
B. J. Adams, B.SC.(MAN.), M.S.(NORTHWEST), PH.D.(NORTHWEST), P.ENG.
P. H. Byer, S.B.(M.I.T.), S.M.(M.I.T.), PH.D.(M.I.T.)
E. Kuhn, DIP.ING.(BRATISLAVA), M.A.SC., P.ENG.
S. Otani, B.ENG.(TOKYO), M.S.(ILL.), PH.D.(ILL.)
R. G. Rice, B.A.SC., S.M.(M.I.T.), PH.D., P.ENG.
J.-C. Roegiers, DIP.ING.(LIEGE), PH.D.(MINN.), P.ENG.

Adjunct, Visiting, and Special Academic Staff
C. Caramanlian, C.ENG.(LEBANON, PARIS), M.ENG., PH.D., *Visiting Assistant Professor*
R. D. Foster, B.A.SC., M.A.SC., P.ENG., *Adjunct Associate Professor*
H. R. Frizzle, B.SC.(N.S.), *Adjunct Associate Professor*
R. C. Hore, B.A., M.A., P.ENG., *Adjunct Associate Professor*
B. Isherwood, B.SC.(BIRM.), P.ENG., *Adjunct Associate Professor*
E. Koczkur, B.SC.(QU.), M.A.SC., PH.D., P.ENG., *Adjunct Associate Professor*
U. Shamir, PH.D.(M.I.T.), *Visiting Professor*

UNDERGRADUATE PROGRAM IN CIVIL ENGINEERING (Program 1)

Civil Engineering as a profession is concerned with improving man's environment through the planning, designing and construction of facilities such as dams, buildings, transportation systems and municipal services. These activities encompass a very wide range of knowledge and this in turn creates special curriculum problems.

The program in Civil Engineering is arranged so that a student may undertake either a relatively broad study of the discipline or a more comprehensive examination of one of its principal fields (structural, municipal and sanitary, transportation, geotechnical, and surveying). This flexibility is derived from the fact that a Fourth Year student's program consists mainly of elective courses and a thesis. The departmental electives are timetabled so as to maximize the freedom of students to take the electives of their choice. Several project-oriented courses provide students with an understanding of the engineering approach to planning and design.

In summary, the program is designed to develop well-informed creative engineers possessing innovative and directive capabilities.

For details of the undergraduate program, refer to Section XI of this calendar.

GRADUATE PROGRAMS IN CIVIL ENGINEERING

Qualified candidates are accepted for advanced studies in geotechnical engineering, sanitary and environmental engineering, structural engineering, transportation engineering and hydraulic engineering. The last is a cooperative program with the Department of Mechanical Engineering.

Additional information can be obtained by writing to the Department of Civil Engineering for a copy of the Graduate Brochure.

DIVISION OF GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

Chairman of the Division:

F. A. DeLory, B.ENG.(McG.), M.A.SC., D.I.C.(IMP.), PH.D.(LOND.), P.ENG., *Professor of Civil Engineering*

Members of the Division:

D. H. Gorman, B.SC.(U.N.B.), PH.D., *Associate Professor of Geology*

G. W. Heinke, B.A.SC., M.A.SC., PH.D.(McM.), P.ENG., *Professor and Chairman, Department of Civil Engineering*

S. W. Holmes, M.SC.(McG.), PH.D.(CORNELL), *Professor of Geology (part time)*

T. C. Kenney, B.ENG.(McG.), D.I.C.(IMP.), M.SC.(LOND.), PH.D.(LOND.), P.ENG., *Professor of Civil Engineering*

R. T. McAndrew, B.SC., M.SC.(QU.), PH.D.(U.B.C.), P.ENG., *Associate Professor of Metallurgy and Materials Science*

A. J. Naldrett, B.A.(CANTAB.), M.SC.(QU.), PH.D.(QU.). *Professor of Geology*

H. U. Ross, C.D., M.SC.(McG.), P.ENG., *Professor of Metallurgical Engineering*

S. D. Scott, B.SC., M.SC.(U.W.O.), PH.D.(PENN.ST.), *Associate Professor of Geology*

D. W. Strangway, M.A., PH.D., F.R.S.C., *Professor and Chairman, Department of Geology.*

Special Lecturer:

G. Anders, DIPL.ING.(CLAUSTAL), PH.D.(TEXAS A&M), P.ENG.

UNDERGRADUATE PROGRAME IN GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE (Program 2)

Geological Engineering and Applied Earth Science is an interdisciplinary program that emphasizes the engineering application of earth science to professional activities related to the materials of the earth. The range of activities involved includes exploration for energy and mineral resources, development and control of the methods of removing minerals from the earth and of processing minerals of yield metals, protection of the environment in the development of earth materials, and geotechnical problems involved in construction with earth materials. Geological Engineering might be summarized as: The combination of the science of geology with the principles of engineering in the use of materials of the earth for the convenience of man in compatibility with the environment.

The program is an interfaculty one, planned and overseen by a council of the teaching staff listed as Members of the Division and four undergraduate students. The specialized core of geological study is provided by the Department of Geology (Faculty of Arts and Science) while several departments in the Faculty of Applied Science and Engineering,

particularly the Department of Civil Engineering and the Department of Metallurgy and Materials Science, contribute instruction in Engineering subjects. The First Year of the four year program is the Engineering curriculum. The Second Year is unique to the Geological Engineering and Applied Earth Science program and emphasizes training in geology, mathematics, basic and material science and acquaints students with the areas of professional activity in the various fields of Geological Engineering. For the Third and Fourth years, students choose one of the three options listed below.

Option A, Mineral Exploration, involves the application of geological (and geophysical and geochemical) principles to the discovery and evaluation of ore deposits. Over the first three years, students are given a thorough grounding in basic geology, including mineralogy, petrology, structure and stratigraphy. In their fourth year, and to some extend during their third, students take more practical courses including Ore Deposit Evaluation, Exploration Geophysics, Petroleum Geology, Mineral Deposits and Exploration Geochemistry. The last three courses are taken together with Arts and Science students, but in the last two, special laboratories and projects devoted to ore deposit evaluation are given in the mineral exploration option. The overall aim of the option is to expose students to the specialized knowledge that they will require to be effective in the mining industry, while at the same time giving them the background of a well-trained geologist.

Option B, Mineral Engineering, which is concerned with the concentration and processing of the valuable contents of the products of mining operations, emphasizes mineralogy in addition to basic physics and chemistry. Specialized courses in mineral benefication, extractive metallurgy, surface chemistry and process design are offered in the third and fourth years of the program.

Option C, Geotechnical Engineering represents the area relating Geology to Civil Engineering, particularly to construction in or of earth materials. The last two years of the program concentrate on the engineering and mechanical properties of earth materials, both rock and soil, and their use as support for structures, as with foundations or as the material of the structure itself, as in dams and tunnels. Civil Engineering courses are included so that the Geotechnical Engineer has a knowledge of structural design, foundations and fluid mechanics. Training is provided to qualify students to identify geological hazards affecting the design and safety of specific engineering projects in or on natural materials. As the engineer has relatively little control over the natural earth materials of construction (e.g. rock, gravel, sand, clay) compared with the man-made materials (e.g. concrete and steel), the program emphasizes recognition, determination and improvement of the material properties.

For details for the undergraduate program, refer to Section XI of this calendar.

DEPARTMENT OF MECHANICAL ENGINEERING

Professor and Chairman of the Department:
D. S. Scott, B.SC.(QUEEN'S), M.SC.(QUEEN'S), PH.D.(NORTHWESTERN), P.ENG.

Professor and Associate Chairman:
H. J. Leutheusser, DIP.ING.(KARLSRUHE), M.A.SC., PH.D., P.ENG.

Professors:
W. D. Baines, B.SC.(ALTA.), M.S., PH.D.(IOWA), P.ENG.
F. C. Hooper, B.A.SC., D.I.C.(IMP.COLL.), P.ENG.
J. F. Keffer, B.A.SC., M.A.SC., PH.D., P.ENG.
A. W. Neumann, B.A., DR.RER.NAT.(MAINZ)
F. P. J. Rimrott, DIPL.ING.(KARLSRUHE), M.A.SC., PH.D.(PENN.STATE), DR.ING.(DARMSTADT), P.ENG.
I. W. Smith, B.A.SC., M.A.SC., P.ENG.
J. Vande Vegte, DIPL.ING.(DELFT), M.A.SC., PH.D., P.ENG.

Associate Professors:
A. H. Abdelmessih, B.M.E.(CAIRO), M.S.(OKLAHOMA STATE), PH.D., P.ENG.
A. B. Allan, B.A.SC., M.A.SC., P.ENG.
D. L. Allen, B.SC.(DAL.), B.E.(N.S.TECH.), M.A.SC., PH.D., P.ENG.
I. G. Currie, B.SC.(STRATHCLYDE), M.A.SC.(B.C.), PH.D.(CAL. TECH.), P.ENG.
R. G. Fenton, DIPL.ING.(BUD.), PH.D.(N.S.W.), P.ENG.
R. C. Flanagan, B.SC., M.E.(U.N.B.), PH.D.(U.B.C.), P.ENG.
D. F. James, B.SC.(QUEEN'S), M.S.(CAL.TECH.), PH.D.(CAL.TECH.), M.A.(CANTAB), P.ENG.
D. McCammond, B.SC.(QU.BELFAST), PH.D.(QU.BELFAST), P.ENG.
B. Tabarrok, B.SC.(WOLVER.&STAFF.), D.PHIL.(OXON), P.ENG.
C. A. Ward, B.SC.(TEX.), PH.D.(NORTHWEST.), P.ENG.

Assistant Professors:
D. B. Cherchas, B.A.SC.(U.B.C.), M.A.SC., PH.D., P.ENG.
W. W. Martin, B.A.SC., M.S.(CAL.TECH.), DR.ING.(KARLSRUHE)
R. D. Venter, B.SC.(WITWATER.), M.ENG.(McM.), PH.D.(McM.)

Senior Tutor:
J. Motycka, DIPL.ING.(BRNO), PH.D.(PRAGUE), P.ENG.

UNDERGRADUATE PROGRAM IN MECHANICAL ENGINEERING (Program 3)

The discipline of Mechanical Engineering has developed from the construction of machines beneficial to man. However, the science embraces much more than the basic design, fabrication and operation of these machines. The student in Mechanical Engineering develops a broad expertise through background training in applied mechanics, thermodynamics, fluid mechanics, control theory and material science, which are all studies of the physical principles on which the machines are based. In addition he receives analytical training in mathematics to provide the means of interrelating the physical

phenomenon and operational concepts. All of the specialities meet in the design process which is taught through the use of projects. One develops the thinking process by which new devices are conceived through the design and fabrication of original machines. It is here that the student must also learn to appreciate social implications of engineering such as concern for the environment, conservation of energy and the economic consequences of his creation.

Virtually the whole spectrum of primary and secondary industries seeks the practising Mechanical Engineer as an employee or a consultant. The largest concentrations are found in the primary power production industry where hydraulic, thermal, and nuclear energy is converted to electricity; in the manufacture of automobiles, aircraft and other mass transportation equipment; in the heating and air-conditioning industry where the environmental control of buildings is established; and in the primary metal producing industries. Some Mechanical Engineers are associated with smaller organizations such as those in the medical equipment and noise control fields, in the management of large and small industries and in education.

The Second and most of the Third Year curriculum in the course is devoted to background studies. Design laboratories are introduced later in the Third Year and carried on throughout the Fourth Year. At the same time, the student can choose electives to suit his talents and inclinations. He can sharpen his understanding of the fundamentals in preparation for graduate work, for employment in research and development areas, or he can concentrate on groups of subjects leading to association with specific industries, such as central power station design or environmental control.

For details of the undergraduate program, refer to Section XI of this calendar.

GRADUATE PROGRAMS IN MECHANICAL ENGINEERING

For students intending to specialize in a discipline of Mechanical Engineering, the graduate Department offers the degree of Master of Engineering (M.Eng.), Master of Applied Science (M.A.Sc.) and Doctor of Philosophy (Ph.D.). The M.Eng. is also offered on a part-time basis and is thus particularly suitable for engineers-in-training in industry. Admission into the graduate program is normally granted graduates with honour standing. The programs offered included the specialist disciplines of the Mechanical Branch of the Association of Profession Engineers of Ontario. Qualified candidates are accepted for specialized study in many areas including: Fluid Mechanics and Hydraulics, Heat Transfer and Thermodynamics, Mechanics and Dynamics, Vibrations and Acoustics, Elasticity, Plasticity and Viscoelasticity, and research topics currently under investigation in the Department.

Additional information is contained in the Departmental Graduate Programs Booklet, which may be obtained at the Department Office.

DEPARTMENT OF INDUSTRIAL ENGINEERING

Professor and Chairman of the Department:
B. Bernholtz, M.A., PH.D.(CAL.TECH.), P.ENG.

Associate Professor and Assistant Department Chairman:
R. W. P. Anderson, M.A.SC., P.ENG.

Professors:
J. W. Abrams, A.B.(CALIF.), PH.D.(CALIF.), P.ENG.
P. J. Foley, M.A.(GLASGOW)
J. W. Senders, A.B.(HARV.)
J. G. C. Templeton, B.A., A.M.(PRINC.), PH.D.(PRINC.), P.ENG.

Associate Professors:
J. V. Abrham, M.A.(CHARLES), PH.D.(CHARLES)
J. A. Buzacott, B.SC.(SYDNEY), B.E.(SYDNEY), M.SC.(BIRM.). PH.D.(BIRM.)
S. H. Cohn, M.A.
A. A. Cunningham, M.A.(OXFORD), PH.D.(ADELAIDE)
E. E. Pickett, B.A.SC., M.A., PH.D.
M. J. M. Posner, B.A.SC., PH.D., P.ENG.
J. S. Rogers, B.SC.(DAL.), M.S.(STAN.), PH.D.(STAN.), P.ENG.
I. B. Turksen, B.S.(PITTS.), M.S.(PITTS.), PH.D.(PITTS.), P.ENG.

Cross-appointed Academic Staff
M. G. Evans, B.SC., M.SC.TECH.(MANCH.), M.I.A., PH.D.(YALE), *professor* (MANAGEMENT STUDIES)
A. Kruger, B.A., PH.D.(M.I.T.), *professor* (WOODSWORTH COLLEGE)

Adjunct, Visiting, and Special Academic Staff:
J. P. Rives, B.SC.(OKLAHOMA), M.SC.(KANSAS), P.ENG., *adjunct associate professor*
H. Schipper, B.A.SC., M.D., F.R.C.P.(C), *part-time tutor*
R. E. L. Seal, M.SC.(BIRM.), P.ENG., *special lecturer*
J. R. Walter, M.A., M.B.A., *adjunct associate professor*
R. C. Whitney, B.A., M.A.(QUEEN'S), *special lecturer*

UNDERGRADUATE PROGRAM IN INDUSTRIAL ENGINEERING (Program 4)

Industrial Engineering is concerned with the analysis, design, improvement and operation of integrated systems of people, materials, equipment and information. This discipline crystallized when it became clear that certain modern technical fields, including operational research, control theory, computer science, probability and statistics, systems theory, and human factors engineering constituted a body of knowledge particularly useful in the operation and management of modern business, industry and government.

As a logical outcome of this development, the program in Industrial Engineering was established in 1958 to provide graduates in engineering specializing in the theory and practice of these subjects. This specialization rests upon a substantial foundation in science and mathematics, in fundamental engineering disciplines including applied ther-

modynamics, electric science, mechanics of materials, materials science, and automation, and in such subjects as economics, organizational structure, financial control and the behavioural sciences.

The curriculum in Industrial Engineering allows, but does not require, each student to take a Technical Elective outside the Department in each of Second, Third and Fourth Years.

Students are urged to select their electives with care, in order to improve their general engineering education or their knowledge of an area in which they wish to specialize. A list of areas of concentration and corresponding recommended subjects is included in the Industrial Engineering handbook, available from the Departmental Office.

For details of the undergraduate program, refer to Section XI of this calendar.

GRADUATE PROGRAMS IN INDUSTRIAL ENGINEERING

The Department of Industrial Engineering offers opportunities for graduate study and research in Human Factors Engineering, Operational Research/Management Science, Computers and Information Systems, Queueing Theory, Applied Statistics, Mathematical Programming, Production and Inventory Control, Engineering Economic Systems, Operational Research in Health Care Delivery, Environmental Sciences and Engineering Decision Theory. Programs offered lead to the M.Eng., M.A.Sc. and Ph.D. degrees.

DIVISION OF ENGINEERING SCIENCE

Chairman of the Division:

F. C. Hooper, B.A.SC., D.I.C.(IMP.COLL.), P.ENG. (*Professor of Mechanical Engineering*)

Associate Chairman of the Division:

O. Trass, B.S.E.(PRINC.), SC.D.(M.I.T.), F.C.I.C., P.ENG. (*Professor of Chemical Engineering*)

Members of the Division:

R. M. Farquhar, M.A., PH.D., F.R.S.C. (*Professor and Associate Chairman of Physics*)

J. J. Horning, B.A., (P.U.C.), M.S.(CALIF.), PH.D.(STAN.) (*Associate Professor of Electrical Engineering*)

R. E. Jervis, B.A., M.A., PH.D., F.C.I.C., F.I.A.F.S., P.ENG. (*Professor of Chemical Engineering*)

R. Luus, B.A.SC., M.A.SC., A.M., PH.D.(PRINC.), F.C.I.C., P.ENG. (*Professor of Chemical Engineering*)

B. Ramaswami, B.SC., D.I.I.SC., M.A., PH.D.(HARV.) (*Associate Professor of Metallurgy and Materials Science*)

A. Sedra, B.SC.(CAIRO), M.A.SC., PH.D., P.ENG. (*Associate Professor of Electrical Engineering*)

R. C. Tennyson, B.A.SC., M.A.SC., PH.D., P.ENG. (*Professor of Aerospace Studies*)

J. R. Vanstone, B.A., M.A., PH.D., (NATAL) (*Professor of Mathematics*)

UNDERGRADUATE PROGRAM IN ENGINEERING SCIENCE (Program 5)

The Engineering Science program is designed for students primarily interested in the application of science to modern technology who wish to prepare themselves for careers in applied research, development or teaching. The undergraduate course provides excellent preparation for post-graduate work in a wide range of specialities in engineering, science and mathematics, and the majority of graduates from this program do proceed to graduate study. Students who graduate from this program and do not continue their studies are nevertheless well qualified to fill a variety of positions in industry, government and teaching.

The courses offered are of high standard, so that only students with better-than-average ability in, and aptitude for, mathematics and science can expect to succeed in them. For this reason, admission is granted only to those who have achieved high standing in their previous academic work, and continuation in the program requires a minimum of 60% at the end of the first term and 66% at the end of the second term. A student who does not meet these requirements will be permitted to transfer into another Engineering program, subject to the requirements and provisions of the Academic Regulations. A student who successfully completes the First Year in Engineering Science may transfer into any other program in the Faculty. (Thereafter, transfers into other programs in the Faculty can normally be made, subject to some program adjustments.)

The curricula for the first two years of the program are common for all students, with some Technical Electives available in terms 1S and 2S. There are available eight carefully planned options* each of which provides a specialized preparation for a particular branch of applied science. In addition, students have the opportunity to select a program that does not conform to any one of the options, as outlined in Section XI.

The curricula are reviewed and updated by Option Committees, and the program is overseen by the Division Council which is comprised of staff and student representatives from all four years.

The curricula are listed in detail in Section XI of this calendar.

DEPARTMENT OF CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

Professor and Chairman of the Department:
M. E. Charles, B.SC.(LOND.), M.SC., PH.D.(ALTA.), F.C.I.C., P.ENG.

Professor and Associate Chairman of the Department:
J. W. Smith, M.A.SC.(U.B.C.), PH.D.(LOND.), D.I.C.(IMP.COLL.), F.C.I.C., P.ENG.

University Professor:
W. H. Rapson, B.A.SC., M.A.SC., PH.D., F.R.S.C., F.C.I.C., F.T.A.P.P.I., P.ENG.

*For further information about the Aerospace Option, see Section IV.

Professors:

D. G. Andrews, M.A.(CANTAB.), F.I.MECH.E., P.ENG.
D. Basmadjian, DIP.ING.CHEM.(ZURICH), M.A.SC., PH.D., M.C.I.C., P.ENG.
W. H. Burgess, B.CH.E., M.F.S., PH.D.(CORN.), P.ENG.
W. F. Graydon, M.A.SC., PH.D.(MINN.), F.C.I.C., P.ENG.
R. L. Hummel, B.S.(PURDUE), PH.D.(IOWA), F.C.I.C., P.ENG.
R. E. Jervis, B.A., M.A., PH.D., F.C.I.C., F.I.A.F.S., P.ENG.
R. Luus, B.A.SC., M.A.SC., A.M., PH.D.(PRINCETON), F.C.I.C., P.ENG.
W. G. MacElhinney, B.A.SC., M.A.SC., F.C.I.C., P.ENG.
D. Mackay, A.R.C.S.T., PH.D.(GLAS.), F.C.I.C., P.ENG.
R. W. Missen, M.SC.(QU.), PH.D.(CANTAB.), F.C.I.C., P.ENG.
M. R. Piggott, B.SC., A.R.C.S., D.I.C., PH.D.(LONDON), F.INST.P., P.ENG.
S. Sandler, M.A.SC., F.C.I.C., P.ENG.
I. H. Spinner, B.A.SC., M.A.SC., PH.D., F.C.I.C., P.ENG.
O. Trass, B.S.E.(PRINC.), SC.D.(M.I.T.), F.C.I.C., P.ENG.
M. Wayman, M.A., PH.D., F.C.I.C., P.ENG.
H. L. Williams, B.A., M.SC.(WESTERN), PH.D.(McGILL), F.C.I.C., F.R.I.C., F.P.R.I., C.CHEM., P.ENG.
R. T. Woodhams, B.SC., M.SC.(U.W.O.), PH.D.(BROOKLYN P.), S.P.E.

Associate Professors:

D. Barham, B.SC.ENG., D.I.C., A.R.S.M., PH.D.(LOND.)
C. E. Chaffey, B.SC., PH.D.(McGILL), P.ENG.
J. S. Hewitt, B.SC.(QU.), M.SC., PH.D.(BIRM.), P.ENG.
C. R. Phillips, B.E., PH.D.(ADELAIDE), P.ENG.
M. J. Phillips, B.A.SC., M.A., (BRYN MAWR), PH.D.(J.H.U.), P.ENG.

Assistant Professors:

D. G. B. Boocock, B.SC., A.R.C.S., D.I.C., PH.D.(LOND.)
D. E. Cormack, B.A.SC., M.A.SC., PH.D.(CALIF.), P.ENG.
F. R. Foulkes, M.A.SC., PH.D., P.ENG.
M. V. Sefton, B.A.SC., SC.D.(M.I.T), P.ENG.

Cross-appointed Academic Staff:

P. Y. Wang, B.SC., PH.D.(McGILL), *Institute of Biomedical Engineering*

Tutors:

C. C. Barnes, B.SC. (QU.)
A. de P. Iribarne, L.QU., PH.D., (BUENOS AIRES)
R. B. Thompson, B.A.SC., P.ENG.

Adjunct, Visiting and Special Academic Staff:
J. H. Aitken, B.SC.(EDIN.), PH.D., *Adjunct Professor*
R. F. Hunter, B.A.SC., M.A.SC., PH.D., P.ENG., *Adjunct Professor*
A. M. Rozeiu, DIP.CHEM.ENG.(BUCH.), P.ENG., *Tutor Part-time*
J. A. Sovka, B.SC., M.SC., SC.D.(M.I.T.), *Adjunct Professor*
A. J. Szonyi, DIP.ENG.(BUDAPEST), M.A.SC., PH.D., M.B.A., P.ENG., *Adjunct Professor*

UNDERGRADUATE PROGRAM IN CHEMICAL ENGINEERING (Program 6)

Undergraduate study in the Department of Chemical Engineering and Applied Chemistry is an excellent preparation for not only a career as a professional chemical engineer, but also for many careers in applied science. In recent years, many graduates from the Department have pursued such careers in addition to those entering the major chemical and petroleum industries.

The chemical engineer is concerned with the development and operation of processes by means of which matter is chemically altered to a more useful form, and in the design, construction, operation and management of plant in which to effect such changes. In addition to such obviously chemical processes as those encountered in the petroleum refining and petro-chemical industry, a great variety of industrial processes involve chemistry and require the abilities of the chemical engineer.

In order to equip a student to start his professional career as a chemical engineer, the undergraduate course is intended to provide him with training in the principles of the major divisions of chemistry and chemical engineering, together with the essentials of other engineering subjects. An important part of the course is the application of these principles to areas of major engineering interest.

Undergraduate study in the Department of Chemical Engineering and Applied Chemistry is also an excellent preparation for work in fields other than professional engineering. In recent years, many graduates from the Department have pursued careers in law, medicine, business and teaching.

Elective subjects available in the Department allow a particular emphasis to be achieved, for example, in one or more of the following areas: environmental chemistry and engineering, polymer science, wood chemistry, materials science, ceramics, medical engineering, energy production and conservation, analytical chemistry, fluid mechanics, nuclear power engineering, nuclear chemistry, biochemical engineering, optimal control, surface chemistry, combustion, pipeline transportation, separation processes and heat transfer. Specialist courses in other Departments or Faculties may also be selected, e.g. courses in biochemistry and microbiology for a program with a bio-chemical engineering emphasis. In this way, advantage may be taken of the resources within the University and an individual student may arrange his program to suit his desires and career objectives.

In the final year, the topic chosen for the thesis allows the student additional specialization. The thesis serves as an introduction to research and the application of principles to topics of engineering interest, and its nature may vary widely depending on the interest of

the staff and students. It may, for example, be concerned with an experimental laboratory investigation, the design of a process, or a computer study of a chemical system.

For details of the undergraduate program, refer to Section XI of this calendar.

GRADUATE PROGRAMS IN CHEMICAL ENGINEERING

The Department of Chemical Engineering and Applied Chemistry, which also includes nuclear engineering, provides opportunities for students who would like to consider advanced studies beyond the undergraduate level toward the M.A.Sc., M.Eng. or Ph.D. degrees. Over 50 graduate level courses are offered by the Department toward the study requirement of the degree programs.

A wide range of thesis research is available in Applied Chemistry, Chemical Engineering and Nuclear Engineering processes, reflecting the broad spectrum of interests of the academic staff. This includes work in polymers; ceramic and composite materials; environmental and energy-conversion studies; chemical and nuclear reactors; separation processes; kinetics, equilibrium, fluid mechanics, heat and mass transfer in chemical systems; biochemical and biomedical engineering; electrochemistry; nuclear and radiochemistry; pulp and paper technology; pipeline transportation; process control; mathematical modelling of chemical processes; catalysis; and nuclear instrumentation.

The laboratories and facilities for graduate student research are mostly contained in the Wallberg Building which houses the undergraduate laboratories and lecture rooms as well. A broad range of modern facilities and equipment are available for experimental research.

Financial support is provided to graduate students through research grants and/or fellowships, together with some undergraduate teaching in the laboratories.

Undergraduate students interested in postgraduate programs are invited to discuss research activities and graduate studies in the Department with any member of staff at any stage of their undergraduate program. Further information may also be obtained from the Graduate Secretary of the Department in Room 240, Wallberg Building and from the Graduate School calendar.

DEPARTMENT OF ELECTRICAL ENGINEERING

Professor and Chairman of the Department:
K. C. Smith, B.A.SC., M.A.SC., PH.D., P.ENG.

Associate Professor and Associate Chairman of the Department:
V. C. Hamacher, B.A.SC.(WATERLOO), M.SC.(QUEEN'S), PH.D.(SYR.), P.ENG.

Professors:
K. G. Balmain, B.A.SC., M.S.(ILL.), PH.D.(ILL.), P.ENG.
P. P. Biringer, DIP.ING.(BUD.), M.SC.(STOCKHOLM), PH.D., F.I.E.E.E., P.ENG.
P. E. Burke, B.E.(N.S.TECH.), M.A.SC., P.ENG.

E. J. Davison, A.R.C.T., B.A.SC., M.A., PH.D.(CAMB.), P.ENG.

J. M. Ham. B.A.SC., S.M.(M.I.T.), SC.D.(M.I.T.), D.A.SC.(MONTREAL), D.SC.(QUEEN'S), F.I.E.E.E., P.ENG.

K. Iizuka, B.E.(KYOTO), M.E.(KYOTO), M.S.(HARV.), PH.D.(HARV.).

W. Janischewskyj, B.A.SC., M.A.SC., F.I.E.E.E., P.ENG.

E. S. Lee, B.ENG.(McG), M.ENG.(McG), PH.D., P.ENG.

I. McCausland, B.SC.(QU.BELFAST), M.SC.(QU.BELFAST), PH.D.(CAMB.), PH.D., P.ENG.

E. E. Newhall, B.SC.(ALTA), M.SC., PH.D. *(part time)*

S. D. T. Robertson, B.SC.(QU.), D.I.C.(IMP.COLL.), M.A.SC., PH.D., P.ENG.

A. Semlyen, DIP.ENG.(RUM.), PH.D.(RUM.), P.ENG.

J. G. Simmons, B.SC.(LOND.), M.SC.(TEMPLE), D.SC.(LOND.), PH.D.(LOND.), F.INST.P., F.I.E.E., F.I.E.R.E.

G. Sinclair, B.SC.(ALTA), M.SC.(ALTA.), PH.D.(OHIO STATE), F.R.S.C., F.I.E.E.E., F.E.I.C., P.ENG., REG.ENG.(OHIO) *(part time)*

G. R. Slemon, B.A.SC., M.A.SC., D.I.C., PH.D.(LOND), D.SC.(LOND.), F.I.E.E.E., F.I.E.E., P.ENG.

H. W. Smith, B.A.SC., SC.D.(M.I.T.), P.ENG.

W. M. Wonham, B.ENG.(McG.), PH.D.(CAMB.), F.I.E.E.E.

J. L. Yen, B.SC.(CHIAO TUNG), M.A.SC., PH.D., F.R.S.C.

Associate Professors:

M. G. Bassett, B.A.SC., F.I.E.S., P.ENG.

P. I. P. Boulton, B.A.SC., M.A.SC., PH.D., P.ENG.

I. R. Dalton, B.A.SC., M.S.(NORTHWEST.), P.ENG.

S. B. Dewan, B.SC.(PUNJAB), M.E.(ROORKEE), M.A.SC., PH.D., P.ENG.

S. Dmitrevsky, B.A.SC., M.A.SC., PH.D.(HARV.), P.ENG.

A. J. Kravetz, B.SC.(ALTA.), M.A.SC., P.ENG.

V. M. Ristic, DIP.ING.(BELGRADE), MAG.N.(BELGRADE), M.SC.(STAN.), PH.D.(STAN.), P.ENG.

C. A. T. Salama, B.A.SC.(U.B.C.), M.A.SC.(U.B.C.), PH.D.(U.B.C.), P.ENG.

A. S. Sedra, B.SC.(CAIRO), M.A.SC., PH.D., P.ENG.

A. R. Straughen, B.SC.(LOND.), M.A.SC., P.ENG.

A. N. Venetsanopoulos, DIP.ENG.(ATHENS), M.S.(YALE), M.PHIL.(YALE), PH.D.(YALE), P.ENG.

Z. G. Vranesic, B.A.SC., M.A.SC., PH.D., P.ENG.

S. Zukotynski, MAGISTER(WARSAW), PH.D.(WARSAW), P.ENG.

Assistant Professors:

B. C. Moore, B.S.(LOU.), M.S.(CALIF.), PH.D.(CALIF.).

S. Pasupathy, B.E.(MADRAS), M.TECH.(MADRAS), M.PHIL.(YALE), PH.D.(YALE).

S. G. Zaky, B.SC.(CAIRO), M.A.SC., PH.D.

Tutors:
H. Hnik, DIPL.ING.(PRAGUE), M.A.SC.(PRAGUE), M.ENG.
K. Pelonis, B.A.SC., P.ENG.

Instructors:
Z. Dharani, B.A.SC.
N. Terzis, B.A.SC.

Cross-appointed Academic Staff:
Professors:
R. S. C. Cobbold, B.SC.(LOND.), M.SC.(SASK.), PH.D.(SASK.), F.R.S.C., *Institute of Biomedical Engineering*.
D. Tsichritzis, B.S.E.E.(ATHENS), M.A.(PRINC.), PH.D.(PRINC.), *Computer Science*

Associate Professors:
R. M. Baecker, B.S.(M.I.T.), M.S.(M.I.T.), PH.D.(M.I.T.), *Computer Science*
R. Holt, B.E.(CORNELL), M.S.(CORNELL), PH.D.(CORNELL), *Computer Science*
M. L. G. Joy, B.SC., M.A.SC., PH.D., P.ENG., *Institute of Biomedical Engineering*
H. Kunov, M.SC.(DENMARK), PH.D.(DENMARK), P.ENG., *Institute of Biomedical Engineering*
E. Llewellyn-Thomas, B.SC.(LOND.), M.D.(McGILL), C.M. (McGILL), F.R.S.C., P.ENG., *Faculty of Medicine, Institute of Biomedical Engineering*
H. O'Beirne, M.A.(CAMB.), M.A.SC., P.ENG., *Institute of Biomedical Engineering*
K. C. Sevcik, B.S.(STAN.), M.S.(CHICAGO), PH.D.(CHICAGO), *Computer Science*
D. B. Wortman, B.E.(YALE), M.S.(STAN.), PH.D.(STAN.), *Computer Science*

Adjunct, Visiting, and Special Academic Staff:
A. M. Albisser, B.ENG.(McGILL), M.A.SC., PH.D., P.ENG., *adjunct professor*
A. J. Cousin, B.S.(NORTHWESTERN), M.A.SC., PH.D., *visiting assistant professor*
J. Endrenyi, DIPL.E.E.(BUD.), M.A.SC.(WATERLOO), PH.D., *special lecturer*
F. E. Holmes, B.A.SC., M.A.SC., PH.D., *visiting assistant professor*
G. R. Lang, B.SC.(WESTERN), P.ENG., *adjunct professor*
J. D. Lavers, B.SC.(DALHOUSIE), M.A.SC., PH.D., P.ENG., *visiting assistant professor*
W. H. Prevey, B.SC.(ALTA.), P.ENG., *special lecturer*
I. H. Rowe, M.A.SC., D.I.C.(IMP.COLL.), PH.D.(LOND.), P.ENG., *adjunct professor*
R. S. Segsworth, B.A.SC., *special lecturer*

UNDERGRADUATE PROGRAM IN ELECTRICAL ENGINEERING (Program 7)

Electrical Engineers are concerned with all forms of electrical phenomena and applications. The early applications of electricity – the generation, transmission and utilization of electrical energy and the communication of information – are still important, but have been or are likely to be transformed by new applications and potential applications such as

magneto-hydrodynamic generation, transmission by superconductors, and satellite communication. In addition, there are completely new fields of application which were not even envisaged a few years ago. There is a growing demand to complex electrical measuring and control equipment for a wide variety of non-electrical processes, and for electronic computers capable of the rapid processing of large volumes of information and the solving of increasingly complex problems.

Within any of these areas, the Electrical Engineer may be engaged in research, development, design, manufacture, operation or management. He may have to assist other engineers and scientists in widely differing fields by supplying them with techniques or insights unfamiliar to them, as for example, in the developing field of biomedical engineering, or he may have to coordinate the application of many technologies in a single project.

It is obvious then, from the wide range of his possible involvement, that the electrical engineer needs a professional education of great breadth and depth. In the undergraduate course, stress is laid on building a solid foundation of engineering science and design technique. The time limitation requires that only material which is essential can be included; much that might be immediately helpful must be omitted to make room for that which will be relevant for several years. In addition, the undergraduate is given the opportunity of studying non-technical subjects of his own choice.

The electrical engineer make extensive use of mathematical techniques and concepts; mathematics is thus of the utmost importance and a large portion of the course is devoted to it. Fundamental subjects such as mechanics, electrical physics, chemistry and thermodynamics get considerable attention in the early years. The basic electrical engineering subjects (electromagnetic field theory, electronics, machine principles and circuit theory) follow these, with expansion and specialization in the final year. In the final year, students freely select their whole program from a wide range of elective subjects. The under-graduate course is intended to provide a base on which to build the continuing education that is needed throughout the Engineer's career.

Electrical Engineering is characterized by the relatively large proportion of its graduates who proceed to post-graduate study to get advanced training in a particular area. For further information on post-graduate studies, refer to the following paragraphs and to the calendar of the School of Graduate Studies.

For details of the undergraduate program, refer to Section XI of this calendar.

GRADUATE PROGRAMS IN ELECTRICAL ENGINEERING

The Department offers graduate study and research opportunities in a wide range of fields within the Electrical Engineering discipline. The staff, comprising specialists in Biomedical Engineering, Communications, Computers, Control Systems, Power Devices and Systems, Solid State and Electronics, and Wave Sciences, conducts an active research program, including both applied and basic topics. Excellent experimental and computing facilities are available. An interdepartmental program in association with the Department of Astronomy is offered in Radio Astronomy.

Programs available lead to the M.ENG., M.A.SC., and PH.D. degrees. A part-time evening program is available for the M.ENG.

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

Professor and Chairman of the Department:
J. M. Toguri, M.A.SC., PH.D., P.ENG.

Professor and Associate Chairman of the Department:
G. B. Craig, M.A.SC., P.H.D., P.ENG.

Professors:
C. B. Alcock, B.SC., PH.D., A.R.C.S., D.SC.(LOND.), F.R.I.C., F.I.M.M.
K. T. Aust, M.A.SC., PH.D., P.ENG.
S. N. Flengas, B.SC.(ATHENS), D.I.C., PH.D., D.SC.(LOND.), F.C.I.C., P.ENG.
Mrs. U. Martius Franklin, PH.D.(BERLIN)
H. U. Ross, C.D., B.ENG., M.SC., (McG), F.I.M.M., P.ENG.
J. W. Rutter, M.A., PH.D., P.ENG.

Associate Professors:
A. McLean, B.SC., PH.D.(GLAS.), P.ENG.
W. A. Miller, B. ENG., M. ENG., PH.D.(McG.), P.ENG.
B. Ramaswami, B.SC., D.I.I.SC., M.A., PH.D.(HARVARD)
G. C. Weatherly, B.A., PH.D.(CANTAB), P.ENG.

Cross-appointed Academic Staff:
F. D. Manchester, M.SC.(N.Z.), PH.D.(U.B.C.), *Physics*
H. W. Smith, B.A.SC., SC.D.(MIT), P.ENG., *Electrical Engineering*

Adjunct, Visiting, and Special Academic Staff:
K. T. Jacob, B.SC., B.E., PH.D.(LOND.), D.I.C., *special lecturer*
R. T. McAndrew, B.SC.(QU), PH.D.(UBC), P.ENG., *visiting associate professor*
T. R. Meadowcroft, B.A.SC.(UBC), D.I.C., PH.D.(LOND.), *adjunct professor*
L. M. Pidgeon, M.B.E., B.SC.(OXON), PH.D.(McG), F.R.S.C., P.ENG., *special lecturer*
R. M. Pilliar, B.A.SC., PH.D.(LEEDS), P.ENG., *adjunct professor*
R. S. Segsworth, B.A.SC., P.ENG., *special lecturer*

UNDERGRADUATE PROGRAM IN METALLURGY AND MATERIALS SCIENCE (Program 8)

In terms of its diversity and scale of operation, the metallurgical industry in Canada ranks among the world's outstanding industrial achievements; it is also responsible for a considerable portion of the country's economy. In this field of endeavour the metallurgist fulfils an important and useful role in the extraction, fabrication and application of metals and their alloys.

In recent years the needs of modern society have made increasingly severe demands upon materials required for various types of construction. This has led to the develop-

ment of the new field of materials science which applies many of the techniques of the metallurgist and others to the study of a wide spectrum of materials. For example the practical application of nuclear energy is limited only by the availability and costs of materials which can withstand in-pile operation; advances in communications depend upon the development of materials having special electrical and magnetic properties; aerospace travel requires materials capable of withstanding extremes of heat, cold and pressure.

The program is perhaps unique in the Faculty in that it draws heavily on both physics and chemistry. It should, therefore, appeal to students with an interest in either of these basic scientific fields. The program is designed to place primary emphasis upon the fundamental principles of metallurgy, materials science and engineering rather than on the operative conditions of industrial practice. In the Fourth Year, each student prepares a thesis on an experimental problem which, where possible, is related to research in progress within the Department. A wide range of electives in the Fourth Year culminates in a final Term 4S which consists largely of material chosen by the student in consultation with an assigned staff tutor. In this manner, the student may elect courses which emphasize either the industrial or the research aspects of metallurgy, materials science and engineering.

The Department is equipped with modern facilities for the study of the structure and properties of materials. This equipment includes mass spectrometers, x-ray diffraction units, an electron beam microprobe analyzer, electron microscopes, several optical metallographs, and materials preparation and testing equipment. Facilities for mineral processing and for the production and measurement of high temperatures and high vacuum are also available.

For details of the undergraduate program, refer to Section XI of this calendar.

GRADUATE PROGRAMS IN METALLURGY AND MATERIALS SCIENCE

The graduate Department offers Master of Engineering, Master of Applied Science and Doctor of Philosophy degrees in physical metallurgy, materials science, and extractive metallurgy. Detailed information on admission is available from the graduate secretary.

The research equipment includes modern facilities for optical, electron and X-ray metallography, mechanical testing, particle characterization, the production of high temperatures and controlled atmospheres, calorimetric and other thermodynamic measurements at high temperatures, crystal growth, etc. The Department has a well equipped central machine shop with auxillary graduate and undergraduate machining and glass blowing facilities.

Research interests in the Department include process development, physical chemistry of metal extraction, mineral processing, hydrometallurgy, powder metallurgy, solidification and crystal growth, structure and mechanical properties of metallic, ceramic and composite materials and historical studies of ancient materials such as Chinese bronzes.

IV Centres and Institutes

Information is given in Section III about the *departments* and *divisions* of the Faculty, about their staffs and the related undergraduate and graduate programs.*

There are other structural elements of the University, *centres* and *institutes*, that play an important part in the work of education and research in this Faculty. These vary widely in their structure and objectives. They range from having major space and facilities to very little; from being purely undergraduate in function to purely graduate; from being imbedded within a department of this Faculty to major inter-Faculty interdisciplinary entities; from being financed like departments of the Faculty to having very different budgetary arrangements.

Each is described briefly in the following pages. Since, unlike all the others, the academic staff of the Institute for Aerospace Studies have no other appointments, a list of them is included.

INSTITUTE FOR AEROSPACE STUDIES

The University of Toronto has played an important role in the aerospace field since the beginning of manned powered flight. Two of its engineering graduates F. W. Baldwin and J. A. D. McCurdy made the first flight by a Canadian and the first flight in Canada respectively, in 1908 and 1909, in aircraft which they helped to engineer and build. These historical events were achieved only a few years after the famous first flight by the Wright brothers in 1903. For nearly three decades, the University of Toronto has been the only Canadian university to offer a broad and coherent program of studies in the aerospace sciences and engineering at the Bachelor's, Master's and Doctorate levels. This program is designed to prepare its graduates for work in a variety of areas including civil air transportation, design and development of new aircraft, spacecraft, and air-cushion vehicles, and for fundamental research in many of the relevant underlying areas of science. Future Canadian needs for air and surface transportation, earth-satellite applications, fusion, noise and pollution sensing and control and laser technology are significant

*Additional information about graduate programs may be found in the Calendar of the School of Graduate Studies.

factors in determining the content of the courses and the design and research projects undertaken.

The courses of study available comprise a basic four-year program leading to the B.A.Sc. degree, an additional year leading to the M.Eng. or M.A.Sc. degree, and a subsequent Doctoral program. The undergraduate (Bachelor's) program consists of four years in Engineering Science (Aerospace Option 5a), and the post-graduate programs are taken in the Department of Aerospace Science and Engineering of the School of Graduate Studies. The staff at the Institute for Aerospace Studies provides the instruction at the undergraduate and graduate levels in all aerospace-related subjects.

UNDERGRADUATE PROGRAM IN AEROSPACE SCIENCE AND ENGINEERING

The details of the undergraduate program are given in this Calendar (refer to Engineering Science in Section XI) and are seen to consist mainly of intensive studies in the fundamentals of mathematics, physics, and engineering sciences correlated with design, analysis and synthesis activities illustrative of modern engineering practice in the aerospace field. In the final two years, the program is oriented to the special needs of the aerospace field, and includes some specialized courses. Graduates of this program are able to fill a variety of positions in education, industry and government, but the fifth year (see below) is recommended for those who wish to improve their qualifications for employment as aerospace engineers.

The modern aerospace field has diversified into a wide variety of technological areas and in addition to courses in the traditional aerospace areas (aerodynamics, stability and control of aircraft, gasdynamics, mechanics of structures, aeroelasticity, aeroacoustic theory and noise control, engineering design), an opportunity is also provided to study several courses at the applied-physics/aerospace interface (quantum and statistical mechanics, lasers, plasmas, and energy). Students are encouraged to consult a member of the Institute staff in making elective course selections.

GRADUATE PROGRAM IN AEROSPACE SCIENCE AND ENGINEERING

If the student's academic record in the undergraduate program meets the requirements for admission to the School of Graduate Studies, he may pursue during a fifth year a program as a candidate for the M.A.Sc. or M.Eng. degree in the (graduate) Department of Aerospace Science and Engineering. Details of entrance regulations and courses of study are given in the Calendar of the School of Graduate Studies. The facilities of the Institute for Aerospace Studies are available to the student for research or project work. For details of research fields, assistantships, scholarships and demonstratorships, students should consult the Secretary of the graduate department.

It should be noted that a student who has graduated in another branch of Engineering, or in science or mathematics, and who desires to qualify as an Aerospace Engineer may be admitted to the graduate program. In that case the courses leading to the M.A.Sc. or

M.Eng. degree will be arranged on an individual basis so that any deficiencies in undergraduate training are made up.

The facilities of the Institute are available for further graduate study and research leading to the Ph.D. degree.

STAFF OF THE INSTITUTE FOR AEROSPACE STUDIES

Professor and Director of the Institute:

J. H. de Leeuw, DIP.ENG.(DELFT.), M.S. in A.E.(GEORGIA TECH.), PH.D., F.C.A.S.I., F.A.P.S.

Professor and Associate Director:

J. B. French, B.A.SC.; M.SC.(BIRMINGHAM), PH.D., F.R.S.A.

Professors:

B. Etkin, B.A.SC., M.A.SC., D.ENG.(CARLETON), F.R.S.C., F.C.A.S.I., F.A.I.A.A.

I. I. Glass, B.A.SC., M.A.SC., PH.D., F.A.P.S., F.A.A.A.S, F.C.A.S.I., F.A.I.A.A., F.R.S.C.

P. C. Hughes, B.A.SC., M.A.SC., PH.D., F.C.A.S.I.

H. S. Ribner, B.S.(CAL. TECH.), M.S., PH.D.(WASH.), F.A.P.S., F.A.S.A., F.C.A.S.I., F.A.I.A.A.

R. C. Tennyson, B.A.SC., M.A.SC., PH.D.

Associate Professors:

J. D. DeLaurier, B.S.(ILL.), M.S., PH.D.(STAN.)

G. W. Johnston, B.A.SC., M.A.SC., PH.D., F.C.A.S.I.

R. M. Measures, B.SC., A.R.C.S., D.I.C., PH.D.(LOND.)

L. D. Reid, B.A.SC., M.A.SC., PH.D.

P. C. Stangeby, B.SC., M.SC.; DIPL. PLASMA SCI., D.PHIL.(OXON)

P. A. Sullivan, B.E., M.E.(N.S.W.), D.I.C., PH.D(LOND.)

Assistant Professors:

J. A. Hansen, B.A.SC., M.A.SC., PH.D(WATERLOO)

J. W. Locke, B.A.SC., M.A.SC., PH.D.

Lecturer:

A. A. Haasz, B.A.SC., M.A.SC., PH.D.

INSTITUTE OF BIOMEDICAL ENGINEERING

Director: R. S. C. Cobbold

Biomedical Engineering is the application of the concepts and methods of engineering to the study of living organic systems, and to the development of instruments and techniques

for biological and medical practice. The ten-member faculty of the Institute is composed of both engineers and medical scientists. Augmenting this faculty are some 40 associates of the Institute, many of whom act as supervisors of students at the Institute. All full-time students at the Institute are graduate students at the University, registered in one of the Graduate Departments and proceeding towards an M.A.Sc., M.Sc., M.Eng., or Ph.D. degree.

The Institute's laboratories are located in the Rosebrugh Building and the Medical Sciences Building on the St. George campus. These laboratories are designed for the construction and testing of electrical and mechanical experimental equipment; real time, interactive computer applications; small animal surgery; and chemical bioengineering. Since many members of the Institute hold appointments in the several nearby teaching hospitals and medical research centres, much of our research is carried out in these hospitals and centres using facilities which they provide.

The Faculty of the Institute participates in undergraduate teaching through various engineering and medical departments, and, in addition, presents one elective course, ELE 445S, in Biomedical Engineering. At the graduate level, some 14 courses are offered through the Institute. An undergraduate student who is interested in Biomedical Engineering should consider taking ELE 445S and perhaps doing his undergraduate thesis in this area. Many interesting topics are offered by the Faculty each year.

COCKBURN CENTRE FOR ENGINEERING DESIGN

Director: I. W. Smith, Cockburn Professor

This Centre was established by Council in 1972, from the earlier Cockburn Unit in Engineering Design that was formed in 1969 to improve and develop design teaching in the Faculty. It is administered by the Cockburn Professor and an executive group comprising six Cockburn Associates appointed from the staffs of the Department of Chemical, Civil, Electrical, Industrial, and Mechanical Engineering and the Institute for Aerospace Studies. Additionally there are other members of the teaching staff directly concerned with courses developed and given by the Centre, and representatives from industry, the Ontario Government Ministry for Industry and Tourism, and the Association of Professional Engineers of Ontario.

The efforts of the Cockburn Centre are concentrated on undergraduate design education to broaden the capabilities for design management at the baccalaureate level and to provide a base for graduate studies beyond the usual analytic/research format. The overall design process, from problem recognition through synthesis and analysis of alternative solutions, testing of a prototype, selection and presentation of an acceptable answer, is being emphasized, beginning with a First Year course CED101S. Problems are gathered from industry and the community, with as much extramural involvement by the students as possible. Design groups of from two to ten students, preferably combining the skills and interests of more than one engineering discipline, are encouraged to develop a team capability for dealing with complex engineering systems. These students learn about

effective group dynamics, the management of the entire design process, the problems of scheduling construction and testing, and the presentation of completed projects.

The Fourth Year course CED401, which by arrangement with some Departments can take the place of the two-term thesis requirement, provides a unique opportunity for senior students to apply their expertise within an engineering team effort.

COMPUTER SYSTEMS RESEARCH GROUP

Chairman: K. C. Sevcik

The Computer Systems Research Group was established in 1968 under the joint administration of the Department of Computer Science (Faculty of Arts and Science) and Electrical Engineering of the University of Toronto. The major objectives of the Group are to do research and development on the design and operating characteristics of complex computer systems, and to see that the results of these investigations are used to improve information processing in Canadian business and government, as well as in the Universities.

Specific objectives of CSRG include:

- The development of specialized problem-oriented languages and techniques for their efficient implementation, including compiler-compiler systems.
- Research into the problems of producing reliable and efficient computer software, and the development of tools to assist in this process.
- Human-factor engineering of computer systems, both those intended for use by experts, and those designed to be used by people without computer training.
- The development of advanced techniques for graphical communication with computer systems, including systems for computer-produced animated motion pictures.
- Hardware design and the production of specialized devices.
- Liaison with the community.

CSRG membership includes about 25 faculty members with academic appointments in the Departments of Computer Science, Electrical Engineering, and Industrial Engineering, as well as the Faculty of Management Studies, and about 40 graduate students.

INSTITUTE FOR ENVIRONMENTAL STUDIES

Director: F. K. Hare

This Institute coordinates interdisciplinary studies of environmental problems in the University. It has close working relationships with the Faculty of Applied Science and Engineering, and with several other Faculties, but is itself part of the School of Graduate Studies. It also has close links with the federal and provincial governments, and with

international agencies. It is able to help in the work of graduate students in Engineering departments, some of whom are housed in the Haultain Building, I.E.S. headquarters.

The work of I.E.S. is understaken by study groups and working groups, each of which takes some broad environmental problem as its focus of study. Currently active groups include those working on oil and gas, persistent substances, water resources management, water quality, solid waste management, air pollution, and climatic change and human response. Other groups are active in such areas as nuclear technology and environmental impact appraisal. Several of these groups have substantial research funds, and graduate students are involved in the work of most of them. Specialized laboratories are available to support the work, and extensive field programs are mounted. There is also a Great Lakes field station at Baie du Dore, on Lake Huron immediately north of the Douglas Point-Bruce nuclear generating station.

Students from Applied Science and Engineering may well find I.E.S. a convenient way of establishing useful contact with researchers and students from other areas, such as Medicine, Social Sciences and Law. The Institute offers several cross-disciplinary graduate courses, and has a limited number of graduate scholarships available for students working on environmental problems.

CENTRE FOR THE STUDY OF MATERIALS

Chairman: G. B. Craig

The Centre was established in 1970 (under the name Materials Research Centre) as an interdisciplinary research body, in order to further and help coordinate teaching and research in materials in all divisions of the University.

Materials research consists of a blending of science and engineering in a study of the structures, properties and applications of all classes of materials. By its nature the work of the Centre is interdisciplinary, involving collaboration with many graduate departments of the University, and staff in a number of Faculties.

Graduate students wishing to work in the general field of materials should register in the appropriate graduate department of their major discipline under the general regulations of the School of Graduate Studies. In consultation with staff of the Centre and the appropriate department, the Centre will arrange, for individual students, interdisciplinary programs involving more than one department but leading to a degree in one of them.

A brochure describing the facilities of the Centre and graduate work in materials is available from the School of Continuing Studies, or the Chairman of the Centre.

SYSTEMS BUILDING CENTRE

Chairman: M. W. Huggins

The Systems Building Centre was established as an interdisciplinary unit within the Faculty with the objective of improving the building process. Its prime function has been to propose and assist in instruction of undergraduate and graduate courses related to

building science and modular construction. Its staff have also directed the work of graduate students enrolled in departments of the School of Graduate Studies, who wish to do research related to improving the building process.

On its staff are research assistants and technicians who devote full time to research projects carried out by the Centre on behalf of and in cooperation with industry and government.

V Professores Emeriti

PROFESSORES EMERITI

E. A. Allcut, M.SC.(BIRM.), M.E., F.R.A.E.S.,
Professor Emeritus of Mechanical Engineering

J. G. Breckenridge, B.A.SC., PH.D(CAMB.),
Professor Emeritus of Chemical Engineering and Applied Chemistry

C. E. Helwig, M.A.SC.,
Professor Emeritus of Civil Engineering

C. Hershfield, B.SC.C.E.(MAN.), M.A.SC., F.E.I.C.,
Professor Emeritus of Civil Engineering

P. B. Hughes, B.SC.(McG.), D.ENG.(EMBRY RIDDLE),
Professor Emeritus of Mechanical Engineering

L. E. Jones, B.SC.(C.E.),(MAN.), M.A.SC., PH.D., F.I.MECH.E., F.E.I.C., P.ENG.,
Professor Emeritus of Mechanical Enginering

G. K. Korbacher, DIPL.ING.(BERLIN), PH.D.(BRAUNSCHWEIG),
Professor Emeritus of Aerospace Studies

G. R. Lord. B.A.SC., S.M.(M.I.T.), PH.D.,
Professor Emeritus of Mechanical Engineering

O. J. Marshall, B.A.SC., C.E., O.L.S.,
Professor Emeritus of Civil Engineering

W. G. McIntosh, B.A.SC.,
Professor Emeritus of Mechanical Engineering

J. W. Melson, B.A.SC.,
Professor Emeritus of Surveying and Geodesy

C. F. Morrison, B.E.(SASK.), M.S.C.(McG.),
Professor Emeritus of Civil Engineering

G. N. Patterson, B.SC.(ALTA.), M.A., PH.D., LL.D., D.SC., F.R.S.C., F.R.A.E.S., F.C.A.S.I., F.A.I.A.A., F.A.A.A.S.,
Professor Emeritus of Aerospace Studies

L. M. Pidgeon, M.B.E., B.SC.(OXON), PH.D.(McG.), F.R.S.C.,
Professor Emeritus of Metallurgy and Materials Science

A. Porter, M.SC.(MANCH.), PH.D.(MANCH.), F.R.S.C.,
Professor Emeritus of Industrial Engineering

H. R. Rice, B.SC.(QUEEN'S),
Professor Emeritus of Mining Engineering

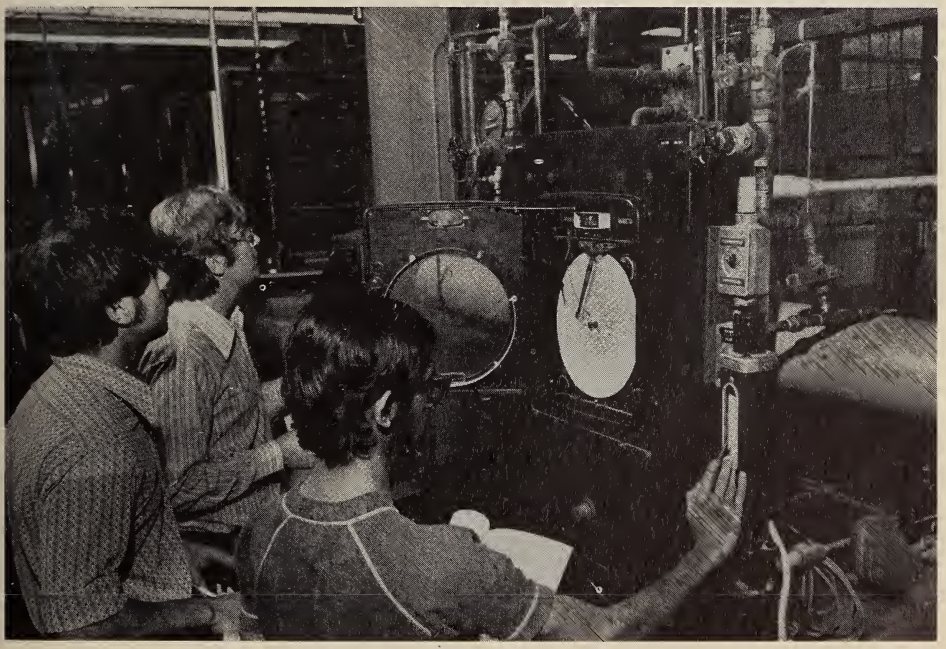
R. S. Segworth, B.A.SC.,
Professor Emeritus of Electrical Engineering

E. A. Smith, M.A.(McM),
Professor Emeritus of Chemical Engineering

G. F. Tracy, B.A.SC., S.M.(M.I.T.),
Professor Emeritus of Electrical Engineering

C. E. Wrenshall, B.E.(SASK.),
Professor Emeritus of Engineering Graphics

W. J. T. Wright, M.B.E., B.A.SC., B.A.,
Professor Emeritus of Engineering Drawing



VI

Officers of the University, 1976-77

Chancellor ..... Eva W. Mader Macdonald, MD, CM, DPH

President ..... J. R. Evans, MD, DPHIL, FRCP[C]
Special Assistant to the President ..... J. H. Sword, BA, MA, LLD

Chairman of the Governing Council ..... Marnie Paikin, BA

Vice-President and Provost ..... D. A. Chant, BA, MA, PH D, FRES, FRSC, LLD
Vice-Provost ..... K. J. Dorrington, PHD, DSC
Vice-Provost ..... M. Israel, BS, MA. PH D
Vice-Provost ..... R. Ross, MBE, MA

Vice-President, Research and Planning ..... G. E. Connell, BA, PH D
Assistant Vice-President ..... G. P. Hiebert, B COM, CA

Vice-President, Business Affairs ..... A. G. Rankin, B COM, FCA

Vice-President, Internal Affairs ..... F. Iacobucci, B COM, LLB, DIP INT LAW

University Ombudsman ..... E. A. McKee, BA, MA

Chief Librarian ..... R. Blackburn, MA, BLS, MS, LLD

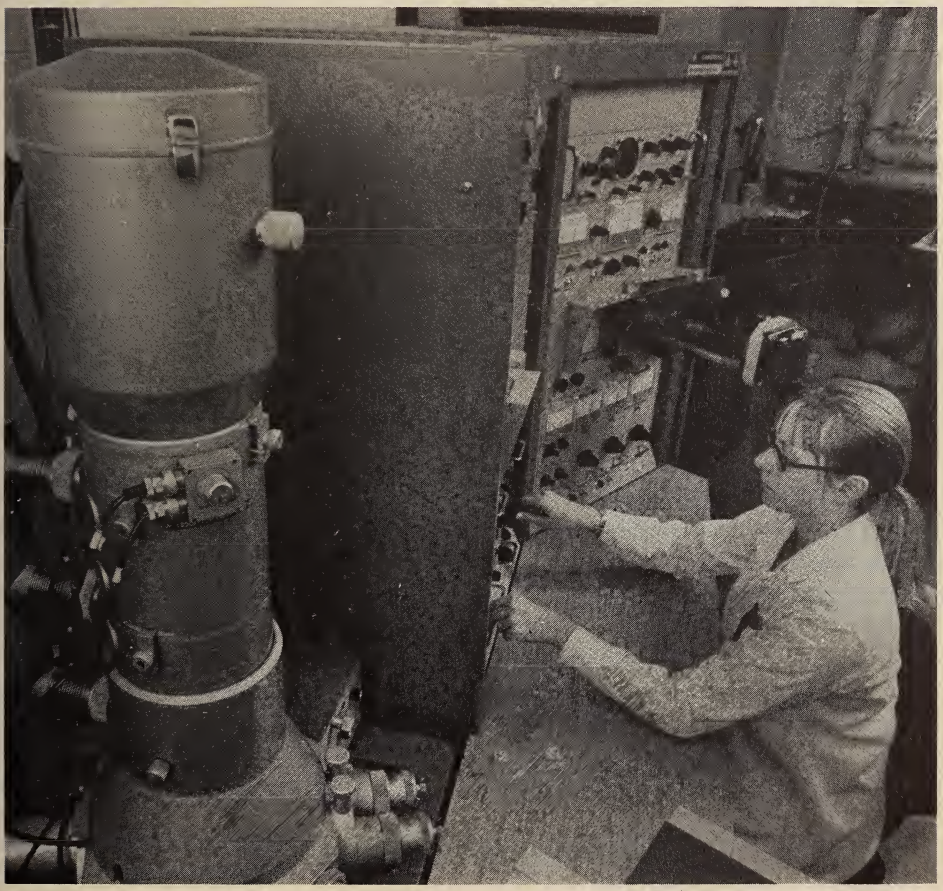
Secretary of the Governing Council ..... D. S. Claringbold

Director of Admissions ..... W. Kent, BA, MA
Director of Student Awards ..... P. S. Phillips, BA, CA
Director of Student Record Services ..... J. C. Wilson, BASC, MSC, PH D

Warden of Hart House ..... J. G. Lengellé, BA, MA, PH D

Coordinator of Campus Services ..... H. L. Reimer, BA, BPAED
Director of Advisory Bureau ..... D. L. McCulloch, BA, MD, DPSYCH, FRCP(C)
Director of Athletics ..... A. J. Fraser, BSC(PE), MA

Director of Career Counselling and Placement Centre .....R. Frankle, BA
Director of University Health Service .....G. E. Wodehouse, MC, MD, FRCP(C), MRCP
Director of Housing Service .....S. Mason, BA
Acting Director of International Student Centre .....E. Paterson, BA



VII General Information: Admission Student Services

Limitation of Enrolment

The Faculty of Applied Science and Engineering reserves the right to limit the number of registrants in any program or course described in this calendar in circumstances where the number of qualified applicants exceeds the teaching and other resources available to the Faculty.

Full details of the University of Toronto undergraduate admission requirements for 1978 are contained in the Undergraduate Admission Handbook 1978–79 available on request from the Office of Admissions, University of Toronto, Ontario, Canada, M5S 1A3 and in all Ontario secondary schools. The 1977 requirements for admission to the First Year of the undergraduate programs in the Faculty of Applied Science and Engineering follow:

1. ONTARIO YEAR 5

Entrance to the First Year of the undergraduate programs is offered, depending upon the number of places available, to candidates from Ontario secondary schools who demonstrate good standing, based upon the following evidence:

1. Completion of secondary school studies, including a full program of academic work at the Year 5 level.
2. A recommendation by the secondary school last attended regarding probable success in university studies.
3. A complete academic report for the last three years of secondary school.

The Year 5 program should include Relations and Functions, Algebra, Calculus, Physics and Chemistry. Superior students, who have completed six credits at the Year 5 level, but whose programs do not include all of these subjects will also be considered. When admissibility is not clear, consideration will be given to evidence of motivation and of ability with language.

In addition, candidates seeking admission to the program in Engineering Science should have excellent standing.

2. CANDIDATES OFFERING CERTIFICATES OTHER THAN ONTARIO YEAR 5:

The following certificates are usually accepted as equivalent to Ontario Year 5 although individual subjects cannot always be equated. The candidates must offer from their final secondary school year, a full Senior Matriculation program including mathematics, physics and chemistry.

Alberta, British Columbia, Manitoba, New Brunswick, Nova Scotia, Saskatchewan — Grade 12
Newfoundland — First Year Memorial University
Prince Edward Island — First Year University of Prince Edward Island
Quebec — C.E.G.E.P.I or equivalent

The following are also accepted as equivalent to Ontario Year 5 although individual subjects cannot always be equated. Candidates applying for admission to the Faculty of Applied Science and Engineering should include mathematics, physics and chemistry in their studies.

United States, Central and South America

First Year University standing (normally 30 semester hours) in acceptable subjects from an accredited institution. Excellent students with high school diploma and C.E.E.B. Advanced Placement Examinations will be considered.

England, West Indies, East and West Africa, Hong Kong

General Certificate of Education, Higher School Certificate or University of Hong Kong Matriculation Certificate showing either passes in five subjects of which at least two must be passed at advanced (or principal) level; or passes in four subjects of which at least three must be passed at advanced (or principal) level. In either case passes are required in physics, chemistry and an acceptable mathematics subject. At least two of these must be at advanced level.

Europe and Commonwealth

A Graduation (Maturity) certificate from the final year of secondary school is required from most European and Commonwealth countries.

India, Pakistan, Bangladesh

Bachelor's degree with standing in the first division.

Japan, Korea, Taiwan

First Year University standing in acceptable subjects from an accredited institution.

Philippines

Second Year University standing in acceptable subjects from an accredited institution.

3. STUDENT VISA APPLICANTS

The Faculty of Applied Science and Engineering admits a limited number of applicants to the first or higher years who come to Canada on student visas. Having regard to the fact that the Faculty cannot accept all qualified applicants for admission, and that its primary responsibility as a public institution is to those who are either Canadian citizens or landed immigrants, the number of places offered to qualified student-visa applicants will not exceed 5% of the total admitted. Of these, no more than half will be accepted from any single country unless there be insufficient qualified applicants to fill the remaining places. These numbers are upper limits, and fewer may be admitted in any given year, depending on the number and qualifications of all applicants to the Faculty. Applicants on student visas must present evidence also of an adequate command of the English language and compete on the grounds of academic merit with all other applicants.

4. ENGLISH FACILITY

In addition to meeting the academic requirements outlined above, non-Canadian applicants whose mother tongue is not English and who have not had their secondary school instruction in a Canadian secondary school for at least two years are required to meet an appropriate standard in a recognized test of English facility such as the University of Michigan English Language Test, the Certificate of Proficiency in English issued by the Universities of Cambridge or Michigan, or the Test of English as a Foreign Language (T.O.E.F.L.). The University of Toronto is a sponsoring agency for the University of Michigan English Language Test and information about the test is sent to any applicant of whom it will be required.

5. NON-MATRICULANTS (MATURE STUDENTS)

For information regarding admission as a non-matriculant (mature student), please consult the Office of Admissions.

6. APPLICATION PROCEDURES

Candidates currently in Ontario Year 5 should apply through their high school using the general application for admission of the Ontario Universities' Application Centre.

All other candidates should write to the Office of Admissions, giving details of their previous academic work. If, after evaluation, a candidate appears eligible for admission consideration, he will receive an official application.

7. FINAL DATE FOR SUBMISSION OF APPLICATIONS

Ontario Year 5 students wishing to be considered for early admission should ensure that their applications are forwarded by their schools to the Ontario Universities Application

Centre not later than December 31. The final date for the receipt of all other applications is April 1.

8. CANDIDATES WHO HAVE PREVIOUSLY FAILED IN UNIVERSITY WORK

Candidates with a previous failure in university work may be considered individually on their merits; candidates with two previous failures are normally refused admission.

9. PROCEDURE FOR REGISTRATION

Detailed instructions concerning registration will be mailed to returning and newly admitted students before the beginning of each academic year.

STUDENT SERVICES AND FACILITIES

For information on such matters as residence accommodation, health service, career counselling and placement, and other services available to students of the University of Toronto, refer to the booklet "Welcome to University of Toronto", obtainable on request from the Office of Admissions, University of Toronto, Toronto M5S 1A3, or from the Secretary, Faculty of Applied Science and Engineering, University of Toronto, Toronto M5S 1A4.

VIII Medals, Prizes, Scholarships and Bursaries

Through the generosity of friends of the University, governments and commercial organizations, encouragement has been given to undergraduate work in the various branches of engineering study by the establishment of the scholarships, prizes, bursaries and medals listed in the following pages.

ADMISSION SCHOLARSHIPS AND BURSARIES

Ontario Students:

Scholarships and bursaries available to students entering the First Year are listed on page VIII–3. For full details concerning these awards, applicants should consult the Calendar of Admission Awards, which is available at Secondary Schools or from the Office of Student Awards, Simcoe Hall, University of Toronto. Applications, which must be made through the Principal of the Secondary School, close in April.

Non-Ontario Students:

All non-Ontario students should apply to the Office of Student Awards, Simcoe Hall, University of Toronto. A limited number of scholarships is reserved for students living outside the Province of Ontario, but as competition is keen such students must not count on receiving assistance but are advised rather to ensure that they have sufficient funds from their own government or from private sources to cover all probable expenses.

IN-COURSE SCHOLARSHIPS AND BURSARIES

Scholarships, prizes, bursaries and loans available to students in attendance in the Faculty are listed on pages 3 to 6 of this section. Where it is necessary to make application for an award it is so stated in the description and particulars are given as to how the application should be made. In all other cases the award is made on the recommendation of the Faculty Council and no application is necessary.

Scholarships, prizes and medals granted in recognition of academic proficiency are awarded at the end of the Spring Term, the candidates being ranked on the basis of their achievement in the Spring Term and the Fall Term previously completed.

To be eligible for any scholarship or award granted solely on academic standing a student must have completed not less than the normal full load within the two terms upon which the award is based. A student whose program in these two terms contains repeated courses will only be eligible if his aggregate of new courses is equal to or greater than 144 units.

Unless otherwise specified in the terms of award, scholarships, medals and prizes based solely upon academic standing will be awarded only to students who have achieved honours in the work upon which the award is granted. If the award is based on a single course or on a part of the work of the term, the candidate must obtain unconditional pass standing in the work of the term, but need not obtain honours on the work of the term unless the terms of the award so specify.

A candidate will not be permitted to hold more than one award in a session unless the statute of each of the awards concerned or the Calendar specifies otherwise. Only one of those awards marked with an asterisk may be held in any one year.

Tuition and residence fees are a first charge against awards. After the deduction of the applicable charges, any balance remaining will be paid to the recipient on November 20. Payment will be made only if the candidate is in regular attendance in the Faculty and, if the Calendar so specifies, in the course in which the award is established or granted.

Medals, after they have been suitably engraved, will be given without delay to the winners or forwarded to them by registered mail.

Awards granted to members of graduating classes other than awards for graduate study and research, will be paid in one instalment as soon as possible after the granting of the awards.

The Governing Council may, on the recommendation of the Faculty, permit a candidate to whom an award has been granted to postpone attendance upon lectures and laboratory classes for one year. Further postponement may be permitted on application.

NOTE – As the value of an endowed scholarship or prize is dependent on the actual income of the fund, it is possible that the value of certain scholarships and prizes at the time of payment may be greater or less than the amount stated in the calendar.

In those cases where the amount of the award is not payable from income earned on an endowed fund, payment will be dependent on the receipt of the amount of the annual award from the donor.

AVAILABLE TO STUDENTS ENTERING THE FIRST YEAR

(† *indicates that application is required. Page numbers refer to pages of this section.*)

Alumni Association War Memorial Scholarships	†	$ 500	page 31
J. P. Bickell Foundation Scholarships	†	$ 500	10
J. W. Billes Admission Scholarships	†		11
Canadian Army Welfare Fund Bursaries	†		12
Children of War Dead Education Assistance	†		13
Engineering Alumni Centennial Admission Scholarships (7)	†	$1000	15
Grabill Admission Scholarship	†	$ 500	17
Hagarty Memorial Scholarship	†	$ 60	18
The Murray Calder Hendry Scholarship	†	$ 500	19
Roy Jarvis Henry Admission Scholarships (3)	†	$ 500	19
J. Edgar McAllister Foundation Admission Awards (30)	†	$1000	20
Lachlan Dales McKellar Admission Scholarships (2)	†	$ 500	22
George R. Mickle Admission Bursaries	†	$1000	23
O.H.A. War Memorial Scholarship	†	$ 200	24
Ontario Student Assistance Program	†		24
A.P.E.O. Admission Scholarship	†	$ 500	25
Regular Officer Training Plan	†		27
Helen E. Rogers Admission Scholarships	†		27
Simpson-Sears Limited (Northern Ontario) Scholarship	†	$ 100	29
Walter Sterling Admission Scholarships	†		30
Wallberg Admission Scholarships (6)	†	$1000	31

AVAILABLE TO STUDENTS COMPLETING THE FIRST YEAR

(† *indicates that application is required. Page numbers refer to pages of this section.*)

Baptie Scholarship		$ 175	9
Canadian Army Welfare Fund Bursaries	†		12
Canadian Bechtel Limited Bursaries	†		10
J. P. Bickell Foundation Bursaries	†		11
T. H. Bickle Prize		$ 30	11
Crocker Foundation Bursaries	†		14
John M. Empey Scholarship		$ 200	15
Engineering Society Centennial Award		$ 100	16
The George A. Guess Scholarships			18
I.B.M. Canada Bursary Plan	†		19
Johnson's Wax Scholarship		$ 800	19
Garnet W. McKee-Lachlan Gilchrist Scholarship in Engineering Science		$ 125	21
MacLennan – MacLeod Memorial Prize		$ 25	22
Ontario Chapter American Society for Metals Bursaries	†		8

AVAILABLE TO STUDENTS COMPLETING THE SECOND YEAR

(† *indicates that application is required. Page numbers refer to pages of this section.*)

Ontario Chapter American Society for Metals Bursaries	†		8
Ontario Chapter American Society for Metals Scholarship		$ 500	8
Ontario Student Assistance Program	†		24
*Professional Engineers Scholarship		$ 250	25
Rhodes Scholarship	†	£1000	26
Frederick W. Schumacher Scholarship	†		28
Edith Tyrrell Memorial Bursary	†	$ 600	30
Wallberg Undergraduate Scholarship		$ 500	32
William R. Worthington Memorial Scholarship		$ 600	33

AVAILABLE TO STUDENTS COMPLETING THE THIRD YEAR

(† *indicates that application is required. Page numbers refer to pages of this section.)*

Stanley Irwin Allen Memorial Scholarship		$ 300	7
American Institute of Industrial Engineers Scholarship		$ 150	8
A.S.H.R.A.E. Bursaries	†		8
Babb Bursary Fund	†		9
F. W. Baldwin Prize		$ 75	9
Canada Student Loans	†		11
Canadian Army Welfare Fund Bursaries	†		12
Canadian Bechtel Limited Bursaries	†		10
J. P. Bickell Foundation Bursaries	†		11
T. H. Bickle Prize		$ 30	11
*Chevron Standard Limited Scholarship		$ 500	13
Chemical Institute of Canada Prize		$ 25	12
Cominco Scholarships	†	$ 800	13
Sydney C. Cooper Bursaries	†		14
Crocker Foundation Bursaries	†		14
The Culliton Scholarship		$ 300	14
Dow Chemical of Canada Limited Award		$ 750	14
John M. Empey Scholarship		$ 200	15
E.I.C. Prize		$ 100	16
Engineering Alumni Centennial Bursaries	†		16
Engineering Society Semi-Centennial Award		$ 100	16
J. A. Findlay Scholarship		$ 100	16
James Franceschini Foundation Scholarship		$ 300	17
George A. Guess Scholarships			18
Chester B. Hamilton Scholarship		$ 500	18
I.B.M. Canada Bursary Plan	†		19
Loan Funds	†		33
J. Edgar McAllister Foundation Bursaries	†		20
J. A. D. McCurdy Prize		$ 75	20
Alexander MacLean Scholarship		$ 250	22

Ontario Chapter American Society for Metals Bursaries	†		8
Ontario Chapter American Society for Metals Scholarship		$ 500	8
Ontario Student Assistance Program	†		24
*Professional Engineers Scholarship		$ 250	25
RCE Memorial Scholarship	†	$ 125	27
Rosedale Chapter, I.O.D.E. Award	†	$ 400	28
Don Salt Memorial Scholarships	†	$ 500	28
Murray F. Southcote Scholarship		$ 100	29
Frederick W. Schumacher Scholarship	†		28
C. H. E. Stewart Bursaries	†		30
Peter S. White Memorial Bursary	†	$ 950	32
Edith Tyrrell Memorial Bursary	†	$ 600	30
Wallberg Undergraduate Scholarship		$ 500	32

AVAILABLE TO STUDENTS COMPLETING THE FOURTH YEAR

(† *indicates that application is required. Page numbers refer to pages of this section.*)

Henry G. Acres Medal			7
A. B. Platt Award, A.S.L.E.		$ 75	8
J. P. Bickell Foundation Bursaries	†		11
Babb Bursary Fund	†		9
Canada Student Loans	†		11
Canadian Army Welfare Fund Bursaries	†		12
Centennial Thesis Awards		$ 50	12
Sydney C. Cooper Bursaries	†		14
Crocker Foundation Bursaries	†		14
Electrical Manufacturing Co. Ltd–Montel Inc. Prize		$ 50	15
IBM Canada Bursary Plan	†		19
Loan Funds	†		33
J. Edgar McAllister Foundation Bursaries	†		20
Massey-Ferguson Ltd. Scholarships (2)	†	$ 250	23
Ontario Student Assistance Program	†		24
Otto Holden Scholarship		$ 900	23
Professional Engineers Gold Medal			25
J. E. Reid Memorial Prize		$ 50	26
Wallace Award, Society of Automotive Engineers Prize		$ 100	29
Society of Chemical Industry Merit Award			29
"Second Mile Engineer" Award	†	$ 200	28
C. H. E. Stewart Bursaries	†		30
W. S. Wilson Medals			32
Peter S. White Memorial Bursary	†	$ 950	32

HENRY G. ACRES MEDAL

The Henry G. Acres Medal is the gift of Mrs. Henry G. Acres in memory of her late husband, Henry G. Acres, M.E., D.Sc., a graduate of the School of Practical Science in the class of 1903. Throughout his professional life Dr. Acres was associated with major power developments in Canada and abroad. As chief hydraulic engineer for the Hydro-Electric Power Commission of Ontario in the period 1911 to 1923, he was responsible for the design and construction of nearly twenty power plants, including the Queenston-Chippewa development. Entering private practice in 1924, and until his death in 1945, he continued to widen and extend his interests. He became chief engineer of the Grand River Conservation Commission and responsible for the design and construction of the Shand dam and related work. Later, he was consulting engineer for the extensive power developments at Shipshaw on the Saguenay River, which was vital to the production of aluminum for war purposes. Many of the provinces of Canada sought his services and he advised with respect to work in Newfoundland, South America and India.

This medal is awarded annually to the student in the Fourth Year who is registered in the course in Civil, Mechanical, or Electrical Engineering, and who obtains the highest aggregate percentage at the annual examinations of the Third and Fourth Years, provided always that the student obtains honour standing in the examinations of the Fourth Year. Receipt of the medal does not preclude a student from being granted such other awards as may in the opinion of the Council be appropriate.

HARVEY AGGETT MEMORIAL SCHOLARSHIP

This scholarship was donated by the late Mr. J. T. Aggett, of Toronto, as a perpetual memorial to his son, the late Lieutenant Harvey Aggett, who enlisted in March, 1915, during his second year in this Faculty, and was killed in action at Passchendaele on November 6, 1917.

This annual scholarship of the value of the annual income from the fund is to be awarded to a student of the Second Year in this Faculty who, obtaining honours and being one of the first three in his year by his standing at the annual examinations, has been adjudged highest of the three in general student activities and service in the University during his period of attendance. When regulations do not permit the winner to hold this scholarship the students to be considered for the award shall be the first three in the year exclusive of any student who holds a scholarship of higher value.

STANLEY IRWIN ALLEN MEMORIAL SCHOLARSHIP

Established by classmates and friends of the late Stanley Irwin Allen, B.A.Sc. 1961, this scholarship, of the value of $300, is awarded to a student in Mechanical Engineering who has demonstrated high academic ability and outstanding scholarship in the work of the Third Year.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS SCHOLARSHIP

The Toronto Chapter, American Institute of Industrial Engineers offers a scholarship of $150 to a student entering the Fourth Year of the Industrial Engineering course. The student must have consistently maintained high, though not necessarily honour standing, during the previous three years, and must be an active member of the University of Toronto Student Chapter of A.I.I.E. The selection will be made on the recommendation of the Chairman of the Department of Industrial Engineering.

A.S.H.R.A.E. BURSARIES

The Ontario Chapter of the American Society of Heating, Refrigerating and Air Conditioning Engineers provides a number of bursaries, to a total value of $1500 annually, for students in the Second and Third Years of Electrical Engineering and Mechanical Engineering. Candidates must reside in Metropolitan Toronto or in an adjacent municipality; the awards will vary in value, according to individual need and the funds available. Application should be made to the Secretary of the Faculty by November 15, on the regular in-course bursary application form.

A. B. PLATT AWARD, AMERICAN SOCIETY OF LUBRICATION ENGINEERS

The Toronto section of the American Society of Lubrication Engineers offers an annual prize of $75 to a student in the Fourth Year in Mechanical Engineering whose Thesis dealing with Lubrication is considered by the Head of the Department of Mechanical Engineering to be of suitable quality and the most satsifactory. The Prize is accompanied by a donation of $25 to the Department to purchase books on Lubrication.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS BURSARIES

The Ontario Chapter, American Society for Metals, provides several bursaries of a value of $150 each for students in all years of Metallurgy and Materials Science and in the Third and Fourth Years of the Materials Science option of Engineering Science. Bursaries are awarded on the basis of academic ability and the need for financial assistance. Applications should be made to the Secretary not later than November 15. The first award was made for the Session 1958–59.

ONTARIO CHAPTER, AMERICAN SOCIETY FOR METALS SCHOLARSHIP

The Ontario Chapter provides one scholarship of a value of $500 for academic excellence to be awarded to a student in Metallurgy and Materials Science after completion of the Second or Third Year, or the Materials Science option of Engineering Science (Third Year). The first award was based upon the results of examininations in the Session 1970–71.

ARDAGH SCHOLARSHIP

The Ardagh Scholarship, of the annual value of the income from $7,500, has been provided in memory of his parents by Professor E. G. R. Ardagh, B.A.Sc., F.R.S.C., formerly professor of Applied Chemistry in the Faculty. It is awarded to the student who attains the highest standing with Honours at the annual examination of the Second Year in the Course in Chemical Engineering. The first award was made on the results of the annual examination of 1946.

ATA TRUCKING INDUSTRY EDUCATIONAL FOUNDATION BURSARIES

The Automotive Transport Association of Ontario has established a bursary fund for students in the second or higher years of any undergraduate degree course who find themselves in serious financial need due to sudden, unexpected personal or family difficulties. Applications may be submitted to the office of Student Awards at any time during the session and the number and value of the bursaries will vary at the discretion of the Committee of Award.

THE BABB BURSARY FUND

Bursaries from this fund are available to students in any year of the Aerospace Option in Engineering Science. Application is made through the Secretary of the Faculty.

THE F. W. BALDWIN PRIZE

The F. W. Baldwin Prize of a value of $75 was established by the trustees of a fund created by the members of Number 3 Squadron, University Air Training Corps (1941–44), in memory of Frederick Walker "Casey" Baldwin, a graduate of the School of Practical Science, who made a significant contribution in the field of Aeronautics in Canada; and who flew, on March 12, 1908, near Hammondsport, N.Y., the "Redwing," the first biplane built by the Aerial Experiment Association.

It is awarded annually to the student registered in Third Year, Aerospace Option, in Engineering Science, who, taking honours, ranks highest in the annual examinations of Third Year in "structural subjects."

The first award was made on the results of the examinations of the Session 1953–54.

BAPTIE SCHOLARSHIP

The Baptie Scholarship is derived from a bequest under the will of the late Mrs. Margaret W. Baptie, of Ottawa, and the Board of Governors has directed that a scholarship of one half the annual income shall be awarded annually to an engineering student on the record of the First Year. The Board of Governors also authorizes a remission of fees in the case of the holder of the scholarship, up to $75.

The conditions of the award are as follows: That the scholarship be awarded to the student who, in the annual examinations of the First Year, enrolled in any of the courses of Civil Engineering, Mechanical Engineering, Chemical Engineering, Electrical Engineering, or Metallurgy and Materials Science, obtains the highest aggregate percentage of marks in those subjects which are common to the First Year curricula of those courses. The first award was made on the results of the annual examinations of the Session 1925–26.

CANADIAN BECHTEL LIMITED BURSARIES

Canadian Bechtel Limited has established Bursaries in the Faculty of Applied Science and Engineering of an annual value of $1,200 to provide two or more awards, each of a minimum value of $150. One award will be made to a First Year student and the remaining awards may go to students registered in any year of the Faculty. Applicants must demonstrate financial need and have academic standing satisfactory of the Faculty Council.

Application must be made to the Secretary of the Faculty on or before November 15.

J. P. BICKELL FOUNDATION SCHOLARSHIPS

The Trustees of the J. P. Bickell Foundation have established scholarships, the number to be determined annually, in the Faculty of Applied Science and Engineering of a possible value of $1,500 payable $500 in the First Year and provided honours are obtained at the annual Examinations, $500 in the Second and Third Years.

An applicant must obtain an average of at least 75% at the Ontario Grade XIII examinations immediately preceding his admission to the University and must undertake to enroll in Chemical Engineering, Metallurgy and Materials Science or Geological Engineering. Failing suitable candidates in the courses mentioned, students registered in the Second Year Honour course in Geological Sciences, or Physics and Geology in the Faculty of Arts and Science who are academically qualified are eligible. These awards are of the same value and are tenable in the Second, Third and Fourth Years of the course, subject to maintenance of the required academic standing. If any scholarships are not awarded to those mentioned above, students registered in the Third Year of the Engineering Science course in the Faculty of Applied Science and Engineering and taking the Physical Metallurgy or the Geophysics option who are academically qualified are eligible. In this case the scholarship will have a value of $1,000, payable $500 in each of the Third and Fourth Years, provided the required academic standing is maintained.

Applications from those entering First Year must be submitted to the Office of Student Awards not later than May 1 on the regular admission scholarship application form. In other cases, applications are not required.

J. P. BICKELL FOUNDATION BURSARIES

The Trustees of the J. P. Bickell Foundation have established the J. P. Bickel Foundation Bursaries in the Faculty of Arts and the Faculty of Applied Science and Engineering. An applicant must be enrolled in Honour Science or in Mathematics, Physics and Chemistry in the Faculty of Arts, in which case he must undertake to study mining or geology in his higher years; or be enrolled in a higher year of an honour course in the geological or geophysical field in the Faculty of Arts; or be enrolled in Chemical Engineering, Mining Engineering, Metallurgy and Materials Science, or Geological Engineering in any year of the Faculty of Applied Science and Engineering. He must demonstrate financial need and have satisfactory academic standing.

Application must be made to the Office of Student Awards on or before November 15.

THE T. H. BICKLE PRIZE

The T. H. Bickle prize is the gift of Mr. and Mrs. E. W. Bickle in memory of their son, T. H. Bickle, an undergraduate of Trinity College and a member of the Senior Intercollegiate Swimming Team at the time of death in 1937. The income from the endowment fund will be used to purchase a suitable prize to be awarded annually to a member of the Senior Intercollegiate Swimming Team of this University in any year, faculty or school. The Committee of Award shall consist of the Dean of the Faculty of Arts, the Director of Athletics, and the Honorary Coach of Swimming. In awarding the Prize the Committee shall consider the character, scholarship, and general interests of the members of the team.

J. W. BILLES ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of J. W. Billes, open to students entering any degree course in the University. The value in each year is a minimum of $250 and a maximum of $1,500 dependent upon the financial need of the recipient. Applicants must satisfy the normal admission scholarship standards in their Grade XIII examinations to be eligible for an award and maintain first class honour standing to enjoy the scholarship in higher years. The number of scholarships awarded in any one year may be varied dependent upon the available funds.

Application should be made to the Office of Student Awards in April on the regular admission scholarship application form.

CANADA STUDENT LOANS PLAN

Full details of this Plan are available in a brochure issued each spring by the Government of Canada. Basically, the plan is designed for those students who have resided in Canada for twelve months and demonstrate financial need, but who do not qualify for assistance under the Ontario Student Assistance Program. Effective 1972, the maximum Canada Student Loan is $1,400 per academic year. The application form for the Ontario Student Assistance Program is also used for the Canada Student Loans Plan.

Application forms and brochures are available from the University of Toronto, Office of Student Awards, and all other post-secondary institutions, and should be submitted to the institution which the student plans to attend.

Students who intend to study outside Ontario or abroad should apply through the Ministry of Colleges and Universities, Mowat Block, Queen's Park, Toronto, Ontario.

CANADIAN ARMY WELFARE FUND BURSARY PROGRAM

This fund provides bursary assistance for full-time attendance at University to dependents of former members of the Canadian Army (Regular) who served between 1 October 1946 and 31 January 1968. Awards are made on the basis of financial need, scholastic ability and length of service. Application forms, to be returned by July 1, may be obtained from the Manager, Canadian Army Welfare Fund, Veterans Affairs Building, Ottawa, Ontario, K1A 0P4.

CARVETH METALLURGICAL LTD. BURSARY

Carveth Metallurgical Ltd. provides one or more bursaries to a total value of $500 for students entering the Third Year of Metallurgy and Materials Science. The award is made primarily on the basis of Second Year standing, but the need for financial assistance will also be taken into consideration.

The Bursary is available every third year, beginning in the Session 1961–62, and is to be awarded on the recommendation of the Department of Metallurgy and Materials Science. Application should be made by letter to the Secretary of the Faculty of Applied Science not later than September 1 of the year in which the award is tenable.

CENTENNIAL THESIS AWARDS

In honour of the Centennial of the founding of the Faculty in 1873, the Centennial Thesis Awards were established in 1972–73 to recognize excellence in Fourth Year thesis work. One award is made annually in each of the Faculty's eight degree programs, based on departmental recommendations, the award being in the form of a $50 prize and accompanying framed certificate. Original funding was provided through the Office of the Dean and is being continued through the generosity of the University of Toronto Engineering Alumni Association.

CHEMICAL INSTITUTE OF CANADA PRIZE

The Chemical Institute of Canada offers a prize of the annual value of $25 in books to the student registered in the course in Chemical Engineering who, having obtained honours, receives the highest standing in the written and laboratory work of the Third Year.

The first award was made on the results of the final examinations of 1947.

CHEVRON STANDARD LIMITED SCHOLARSHIP

Chevron Standard Limited has presented a scholarship of $500 to a student who achieves outstanding results in the annual examinations of the Third Year in the Geophysics Option in Engineering Science or in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and Science.

The awards alternate annually between the Faculties of Applied Science and Engineering (even years) and Arts and Science (odd years). The First Award was made in the session 1960–61 in the Faculty of Applied Science and Engineering.

CHILDREN OF WAR DEAD (EDUCATION ASSISTANCE) ACT

Children of War Dead (Education Assistance) Act provides fees and monthly allowances for children of veterans whose death was attributable to military service. Enquiries should be directed to the nearest District Office of the Department of Veterans Affairs.

5T6 CIVILS SCHOLARSHIPS

The 5T6 Civils, consisting of the graduating members of the 1956 Civil Engineering Class of the University of Toronto, have established an annual scholarship of the value of $300 open to students who have completed the Second Year of the course in Civil Engineering and are registered in the Third Year of the course. The selection of the recipient is based on evidence of the qualities of scholarship, leadership and character. The award is not tenable with any other scholarship of greater value.

The award is presented at the annual reunion of the Class of 5T6 Civils. The first award was made in 1964.

Students who wish to be considered for this scholarship should write to the Class of 5T6 Civil Engineering, c/o Alumni House, University of Toronto, not later than December 31, giving full particulars of their academic record, and their extra-curricular activities both within and outside the University.

COMINCO SCHOLARSHIPS

Two scholarships, of an annual value of $800 each, are provided by Cominco Limited and are offered to students in the Third Year of the courses in Chemical Engineering, Geological Engineering, Mechanical Engineering and Metallurgy and Materials Science in the Faculty of Applied Science and Engineering and to students in the Third Year of the courses in Chemistry and Geology in the Faculty of Arts and Science. The scholarships may be renewed in the Fourth Year if satisfactory standing is maintained.

Application must be made to the Secretary of the Faculty on the regular in-course awards form not later than October 15.

SYDNEY C. COOPER BURSARIES

An amount of $900 is provided annually for bursaries to be awarded to students in the Third and Fourth Years of the program in Civil Engineering who have achieved at least second-class standing in the previous year and who are in need of financial assistance.

Application must be made on the regular in-course bursary application form not later than November 15.

CROCKER FOUNDATION BURSARIES

The income from a capital fund established from the estate of the late Beatrice Crocker Glazier in memory of her brother, James William Crocker, provides bursaries for students in the Faculty of Medicine and the Faculty of Applied Science and Engineering who are in need and are worthy of financial assistance.

Application should be made to the Secretary of the Faculty not later than November 15.

THE CULLITON SCHOLARSHIP

Mr. Peter J. Culliton, B.A.Sc., 2T1, M.A.Sc., 2T3 (Civil Engineering), has graciously donated a sum of $1500 to the Faculty to be used to fund this award. The scholarship, first awarded in 1973–74 will have a value of $300 annually until 1978–79, when the fund will have depreciated and a smaller final award will be made. The scholarship is awarded to the student in Civil Engineering who achieves the highest standing at the annual examinations of the Third Year among those who do not hold an award of higher value.

CYANAMID OF CANADA SCHOLARSHIP

As a part of their program to encourage technical development in Canada, Cyanamid of Canada Limited offers a scholarship of the value of $750 to a student entering the Third Year in Chemical Engineering or Industrial Engineering. The award is made to a student who has demonstrated high academic ability and outstanding scholarship in the work of the Second Year.

The first award at the University of Toronto was made in 1964.

DOMINION AUTO ACCESSORIES LTD. SCHOLARSHIP

Supported by an annual donation from the Buck Family Foundation, this scholarship, of the value of $1000, is awarded to a student entering the Third Year in Industrial Engineering who has achieved high standing, with honours, on the work of the Second Year.

DOW CHEMICAL OF CANADA LIMITED AWARD

Dow Chemical of Canada Limited has provided funds for an annual award of $750 to a student in Chemical Engineering in the Faculty of Applied Science and Engineering, and a

grant-in-aid of $250 to be used in the winner's department to help defray the cost of equipment, supplies and administration.

The winner must:

(*a*) be registered in the Third Year in Chemical Engineering (the award will be made in the second term of the Third Year and will be paid to the winner during his Fourth Year);

(*b*) be in the upper half of the class;

(*c*) have demonstrated leadership in extra-curricular activities.

(*d*) have a sincere interest in the chemical industry.

The award is not tenable with other awards in the gift of the Governing Council. Application is not required.

THE ELECTRICAL MANUFACTURING COMPANY LTD. – MONTEL INC. PRIZE

The Electrical Manufacturing Company Limited has established an annual Prize of $50 in the Faculty of Applied Science and Engineering.

The winner must:

(*a*) be registered in the Fourth Year in Electrical Engineering;

(*b*) obtain the highest aggregate percentage of marks at the final examinations in the subjects of the Fourth Year related to electrical distribution equipment, the subject to be determined by the Head of the Department of Electrical Engineering.

This Prize is tenable with other awards in the gift of the Governing Council.

THE JOHN M. EMPEY SCHOLARSHIPS

The John M. Empey Scholarship Fund was established under a bequest of $10,000 in the Will of the late John Morgan Empey, B.A.Sc., 1903. Three scholarships of equal value are provided from the income from the Fund. One of these scholarships is awarded in each of the First, Second, and Third Years on the results of the annual examinations, to a student who, taking honours, obtains the highest average percentage of marks in the written and laboratory subjects of his Year. The scholarships are open to any students registered in the Faculty. In case the winner of any one of these scholarships does not attend this Faculty during the session next following the award, the right to the scholarship shall be forfeited and the awards shall be made to another eligible student. The scholarships were awarded for the first time in 1944.

ENGINEERING ALUMNI CENTENNIAL ADMISSION SCHOLARSHIPS

Seven scholarships, each of the value of $1000, are provided annually by the University of Toronto Engineering Alumni Association for students entering the First Year of any course in the Faculty of Applied Science and Engineering. The awards are made on the basis of standing in the Ontario Grade XIII examinations.

Application should be made to the Office of Student Awards in April on the regular admission scholarship application form.

ENGINEERING ALUMNI CENTENNIAL BURSARIES

Thanks to the generosity of the Engineering Alumni Association, a number of bursaries have been established in the Faculty of Applied Science and Engineering. These bursaries are awarded on the basis of academic achievement and financial need, with preference being given to students in the Third and Fourth Years.

Application should be made to the Secretary of the Faculty not later than November 15.

ENGINEERING INSTITUTE OF CANADA PRIZE

The Engineering Institute of Canada Prize, of the value of $100, is awarded annually to a Student Member of the Institute on the basis of the marks made at the completion of his penultimate year of undergraduate study, and on his activities in the Engineering Society or in the student branch of a recognized engineering Institute or similar organization.

ENGINEERING SOCIETY CENTENNIAL AWARD

The Engineering Society Centennial Award, to the value of $100, was established in 1973 to commemorate the Centennial of the founding of the School of Practical Science. The award is made to a student entering the Second or Third Years.

The selection is based on the following qualifications, which each bear equal weight in the selection of the winner: (*a*) General "Skule" activities; (*b*) Contributions to the Engineering Society Council; (*c*) Personality, and social and athletic activities. The winner must obtain an unconditional pass standing on the work of the year.

ENGINEERING SOCIETY SEMI-CENTENNIAL AWARD

The Engineering Society Semi-Centennial Award, currently having a value of $100, was established in 1931 to commemorate the first graduating class of the School of Practical Science. The award is made to a student entering the final year.

The selection is based upon the following qualifications, which bear equal weight in the selection of the winner: (*a*) General "Skule" activities; (*b*) Contributions to the Engineering Society Executive Committee; (*c*) Personality, and social and athletic activities; (*d*) Academic Standing.

J. A. FINDLAY SCHOLARSHIPS

These scholarships were established through a legacy bequeathed by the late Miss Janet Findlay to the Department of Mechanical Engineering. Two scholarships are available, each of a value of one half of the income of the fund, to students in this program, one for a student in the Third Year, the other for a student in the Fourth Year, but only if the student continues his course in Mechanical Engineering. The selection will be made, on recommendation of the Head of the Department of Mechanical Engineering, from amongst the four students having the highest average percentage of marks at the annual examinations in the Second and Third years respectively, but in making the award the

student's general character, fitness for his profession, and financial circumstances will be given consideration. In case a student who has been awarded one of the scholarships changes his course or does not attend this University during the next following session, he shall forfeit his right to the scholarship and the award shall be made to another eligible student.

THE JAMES FRANCESCHINI FOUNDATION SCHOLARSHIP

This scholarship, of a value of $300, is awarded to the student in Civil Engineering who achieves the highest standing, with honours, at the annual examinations of the Third Year among those who do not hold an award of a value of $100 or more based on the results of these examinations.

HUGH GALL AWARD

The Hugh Gall Award was established in 1946 by the graduate Class of 1910 "to commemorate a deceased classmate who was a splendid type of student, a loyal friend, and nationally outstanding in athletic achievement during his undergraduate career." Upon expiration of the original gift in 1951 the award was supported by Mrs. Hugh Gall until her death in 1970; under the terms of her will a sum of $5,000 was provided to support the award in perpetuity, the annual value of the award being the income from the bequest. The award is made to a student who, having completed his First Year with a general average of at least 66% without conditions, has entered the Second Year, and is in special need of financial assistance in order to enable him to continue his course. It is desirable, but not necessary, that the recipient shall not already have been given any other scholastic award or scholarship applicable to the Second Year and he shall have shown indications of his firm intention and ability to follow successfully the profession of engineering.

Any Second Year student in the Faculty of Applied Science and Engineering is eligible to apply for this Bursary. Applications should be made to the Secretary of the Faculty not later than November 15.

THE GENERAL MOTORS SCHOLARSHIPS

Provided by General Motors of Canada Ltd., a scholarship of $1,000 is awarded annually to the student entering the Third Year of the program in Mechanical Engineering, who being a Canadian citizen, has demonstrated the highest academic and leadership qualities. The scholarship is renewable for the Fourth Year, provided that the recipient maintains satisfactory academic standing. Another scholarship of equal value is awarded annually to a student in the Faculty of Arts and Science.

THE GRABILL ADMISSION SCHOLARSHIP

The Grabill Admission Scholarship is the gift of Mr. Dayton L. Grabill, a graduate of this Faculty in 1924. The Scholarship has a value of approximately $500. It is awarded to the candidate who has standing amongst those with the highest average percentages in the

subjects of Ontario Grade XIII required for admission to the Faculty of Applied Science and Engineering. The candidate must write the Grade XIII examinations at one sitting in the June preceding entry to the University after not more than one year's instruction in Grade XIII and must register in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards on the regular Admission Scholarship form in April.

THE REGINALD AND GALER HAGARTY SCHOLARSHIP

The Reginald and Galer Hagarty Scholarship was first awarded in 1945 in memory of the sons of Lieutenant-Colonel E. W. Hagarty and Charlotte Ellen Hagarty, his wife. It has the value of the annual interest on the capital sum of $2,000 and is awarded to a student who has completed Grade XIII at Harbord Collegiate Institute. Further details are available from, and application should be made to, the Office of Student Awards in April.

THE GEORGE A. GUESS SCHOLARSHIPS

The estate of Edna F. Guess, wife of George A. Guess, formerly Head of the Department of Metallurgical Engineering, has bequeathed funds to the University for the purpose of establishing the George A. Guess Memorial Fund for the assistance of needy students of Metallurgy. The annual income of the Fund is used to provide graduate fellowships, summer studentships and an undergraduate fund in the Department of Metallurgy and Materials Science in addition to the George A. Guess Scholarships.

A maximum of six George A. Guess Scholarships may be awarded annually, each having a value of the regular tuition and incidental fees. The awards are made to students who have achieved high academic standing (not less than 80%) who are in need of financial assistance, and who do not hold another academic award.

Three awards are made to students entering the Second, Third or Fourth Years of Metallurgy and Materials Science, two awards to students entering the Third or Fourth years of the Materials Science Option of Engineering Science and one award to students entering the Third or Fourth Years of the Mineral Engineering Option of Geological Engineering. If there are insufficient numbers of qualified students in any of the eligible programs, then the remaining awards may be distributed to qualified students in either of the other two programs. If six awards are not made in any year, the residual sum will remain in the George A. Guess Fund to be used for one of the purposes stated above. The first awards will be made on the results of the examinations of 1974–75.

CHESTER B. HAMILTON SCHOLARSHIP

Members of the family of the late Chester B. Hamilton, a graduate of the Faculty in 1906, have presented a Scholarship in his memory of the annual value of $500. It is held by a Fourth Year student in Mechanical Engineering who has achieved outstanding academic standing at the Annual Examinations of the Third Year.

The first award was made on the results of the examinations for the Session 1958–59.

THE MURRAY CALDER HENDRY SCHOLARSHIP

This award was established by the estate of Mrs. Grace Appel Hendry as a memorial to her husband, a graduate of this Faculty in 1905. It has a value of the income from a capital sum of $10,000 and the recipient must:
(*a*) have attained an average of at least 75% on the grade XIII examination papers, written at one sitting, required for admission to the Faculty.
(*b*) be entering the First Year of any course in the Faculty of Applied Science and Engineering.

Application must be made to the Office of Student Awards in April on the regular University Admission Scholarship Application form.

The first award was made in the Session 1962–63.

ROY JARVIS HENRY ADMISSION SCHOLARSHIPS

The estate of the late Roy Jarvis Henry provides three scholarships of the value of $500 each, to be awarded to students who have achieved high standing on the Ontario Secondary School qualifications required for admission, two of which are open to students entering any course in the Faculty and one open to students entering Geological Engineering. In the lack of a suitable candidate in Geological Engineering, all three awards are tenable in any course in the Faculty. Application must be made on the regular admission scholarship application form.

HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO BURSARY

The Hyrdo-Electric Power Commission of Ontario has provided a bursary of the value of $500, which may be awarded to a student entering the Second Year of the courses in Mathematics and Physics or Commerce and Finance in the Faculty of Arts and Science, or any course in the Faculty of Applied Science and Engineering. Application should be made on the regular in-course bursary form not later than November 15.

IBM CANADA BURSARY PLAN

International Business Machines Company Limited has made available one or more bursaries of a total annual value of $1,000 to students registered in any year of a full time course in the University who have standing satisfactory to the Committee of Award and demonstrate financial need.

Application should be made to the Office of Student Awards by November 15.

JOHNSON'S WAX SCHOLARSHIP

S. C. Johnson and Son Limited, Brantford, Ontario, have established a Scholarship of an annual value of $800 in each of the Second, Third and Fourth Years or a total possible value of $2,400.

The recipient must:

(*a*) be registered in Chemical Engineering in the years in which the Scholarship is awarded and held;

(*b*) in the opinion of the Council be the most promising and deserving member of the class, obtaining Honours in the final examinations of the First Year;

(*c*) in his Second and Third Year, maintain academic standing satisfactory to the Council, not necessarily Honours, for the continued enjoyment of the Scholarship. In its discretion the Council may recommend the award of any portion of the Scholarship lost by the original recipient by failure to maintain satisfactory academic standing, to another student of the year(s) in which the Scholarship would otherwise have been enjoyed.

The first award was made on the results of the annual examinations written in April 1954. It is not tenable with any other Scholarship.

J. EDGAR McALLISTER FOUNDATION BURSARIES

Through the generosity of the late J. Edgar McAllister, a graduate of the Faculty in 1895, a fund has been established in the University to be known as the J. Edgar McAllister Foundation, to provide financial aid for students who require it, in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science. Application should be made on the regular in-course bursary form not later than November 15.

J. EDGAR McALLISTER FOUNDATION ADMISSION AWARDS

Provided for by the bequest of the late J. Edgar McAllister, B.A.Sc., twenty-five awards of the value of $1,000 each are available to students entering the First Year of the programs in Mechanical, Chemical, Electrical and Geological Engineering and Metallurgy and Materials Science, who have achieved high standing in the secondary school courses prescribed for admission and who are in need of financial assistance.

Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto Scholarship Application form, which is to be submitted in April.

THE J. A. D. McCURDY PRIZE

The J. A. D. McCurdy Prize of a value of $75 was established by the trustees of a fund created by the members of the Number 3 Squadron, University Air Training Corps (1941–44) in honour of John Alexander Douglas McCurdy, a graduate of the School of Practical Science, who "made the first flight in Canada on February 23, 1909, with a heavier-than-air machine."

It is awarded annually to the student registered in Third Year, Aerospace Option, in Engineering Science, who, taking honours, ranks highest in annual examinations of the Third Year in the subjects related to Aerodynamics.

The first award was made on the results of the examinations of the Session 1953–54.

THE GARNET W. McKEE-LACHLAN GILCHRIST SCHOLARSHIP IN ENGINEERING SCIENCE

Mrs. Garnet W. McKee and Professor Lachlan Gilchrist each contributed $1,000 to provide for a Scholarship in the First Year of the course in Engineering Science.

The value of the Scholarship is the annual income from the capital fund and is awarded to the student who ranks first in honours at the annual examinations of the First Year in the course in Engineering Science. If for any reason that student is ineligible to hold the Scholarship, it will be awarded by reversion to the student ranking second in honours in the course. In order to receive payment the winner must register in the Second Year of the course in Engineering Science. The Scholarship was awarded for the first time on the results of the annual examinations of 1947.

THE GARNET W. McKEE-LACHLAN GILCHRIST GEOPHYSICS SCHOLARSHIPS

Financial assistance was received by Professor Lachlan Gilchrist of the Department of Physics, University of Toronto, from certain organizations and individuals to help him in the prosecution of his research work in Geophysics. With the consent of the contributors, the unexpended balance of these gifts was transferred by Professor Gilchrist to the Board of Governors of the University to be used as an endowment for scholarships, two of which were established in the Faculty of Applied Science and Engineering. To this fund have been added additional amounts received from the estate of the late Garnet W. McKee and from the Hollinger Consolidated Gold Mines Ltd. They are awarded by the Governing Council, on the recommendation of the Council of the Faculty of Applied Science and Engineering. The first awards were made on the results of the Annual Examinations of 1941.

The First Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $250 is awarded to the student in the Second Year in the course of Engineering Science who obtains the highest aggregate standing at the examinations of the First and Second Years in the course, provided always that the student obtains honour standing at the examinations of the Second Year.

The Second Garnet W. McKee-Lachlan Gilchrist Geophysics Scholarship. This scholarship, of the annual value of $190 is awarded to the student in the Second Year in the course of Engineering Science who, of those students who elect to proceed in the Third Year in the Geophysics Option of the course, obtains the highest aggregate standing at the examinations of the First and Second Years, provided always that the student obtains honour standing at the examinations of the Second Year, and excluding always the student to whom the First Lachlan Gilchrist Geophysics Scholarship has been awarded.

If in any year there is no student who has fulfilled the condition as laid down for the Second Lachlan Gilchrist Geophysics Scholarship, it shall be awarded to the student in the Second Year in the course in Engineering Science who obtains the second highest aggregate standing at the examinations of the First and Second Years of that course, provided always that such student obtains honour standing in the examinations of the Second Year.

LACHLAN DALES McKELLAR ADMISSION SCHOLARSHIPS

Provided by a bequest of the late Leona D. McKellar, two scholarships of the value of $500 each, are offered to students who have achieved high standing on the Ontario Secondary School qualifications required for admission to the Faculty. Application must be made on the regular admission scholarship application form.

THE ALEXANDER MACLEAN SCHOLARSHIP

This scholarship was established by graduates of the University of Toronto and other friends in honour of Professor Alexander MacLean, B.A. (1908) who retired in 1954. The scholarship, of the value of $250, is awarded to a student in the Third Year of Geological Sciences, Faculty of Arts, or in the Third Year of Geological Engineering, Faculty of Applied Science and Engineering, who, obtaining not less than 75% in the work of the year, obtains the highest standing in the geological subjects common to the two courses.

The first award was made in 1955.

MACLENNAN-MACLEOD MEMORIAL PRIZE

The Graduating Class of 1910 has donated an annual prize, known the "The MacLennan-MacLeod Memorial Prize," in memory of their first Class President, George MacLennan, who was killed in action in France in 1917, and of Doug. MacLeod, their first Secretary, who died in France in 1916 from wounds received in action.

The prize, of the value of $25, is awarded to the First Year student in the Faculty of Applied Science and Engineering who ranks highest in Calculus among those who obtain standing without condition at the annual written examinations; or, in the event of more than one student obtaining equally high rank in Calculus, the award is made to the one of these who also has the highest standing in some other subject common to the competitors, such as Algebra, such subject to be determined by the Council of the Faculty.

An award will not be made in any year in which, in the opinion of the Council, no student obtains a sufficiently high standing in Calculus to merit the award. If in any year no award is made, a second award will be available in the subsequent year.

CHARLES GORDON MANNING PRIZE

The Charles Gordon Manning Prize was established by a bequest under the Will of the late Jennie Manning in the amount of $500, the annual income from which is to be used to buy books for the winner of the Prize.

The recipient must be enrolled in the Second Year of a course offered by the Faculty of Applied Science and Engineering and, in the opinion of the Council, rank second to the student awarded the Harvey Aggett Memorial Scholarship in the considerations specified for the award of that Scholarship, namely, obtaining honours in his final examinations and being one of the first three in his year by his standing at those examinations relative to the

pass requirements in his Department and being "adjudged highest of the three in general student activities and service in the University during his period of attendance."

The first award was made on the results of the annual examinations of 1954.

MASSEY-FERGUSON LIMITED SCHOLARSHIPS

Massey-Ferguson Limited has established two scholarships each of an annual value of $250, to be awarded on the recommendation of the Council of the Faculty of Applied Science and Engineering to students registered in the Fourth Year of the courses in Mechanical Engineering or Industrial Engineering. In making the award academic achievement, financial need, extra-curricular activities and such other factors as may be deemed appropriate will be taken into consideration.

Application should be made to the Secretary of the Faculty not later than November 15.

GEORGE R. MICKLE ADMISSION BURSARIES

Provided for by a bequest of the late George R. Mickle, five bursaries of the vaue of $1,000 each are available to student entering the First Year of courses in the Faculty of Applied Science and Engineering. The awards are made on the basis of the applicant's academic standing in Grade XIII, and his need for financial assistance. Applicants wishing to be considered for these awards should complete the financial need section on the regular University of Toronto admission awards application form.

JAMES L. MORRIS MEMORIAL PRIZE

The James L. Morris Memorial Prize is the gift of Mrs. J. H. Craig and Mr. J. R. Morris, K.C., in memory of their father, James L. Morris, C.E., O.L.S., D.Eng., the first graduate of the School of Practical Science, who died in 1946 after a distinguished career.

Graduating in Civil Engineering in 1881 as the sole member of his class, Dr. Morris engaged in railway work for some time, first as an engineer and then as a contractor. For 43 years he conducted a successful civil engineering practice in Pembroke, Ontario, involving important undertakings in the field of municipal power and bridge work.

This Prize, of the value of the annual income from $3,000, is awarded annually to the student in the Second Year of the Course in Civil Engineering who obtains the highest aggregate percentage at the annual examinations of the First and Second Years of the course, provided always that the student obtains honour standing at the Examinations of the Second Year.

OTTO HOLDEN SCHOLARSHIP

Otto Holden, B.A.Sc., C.E., D.Eng., was a distinguished hydraulic engineer of international reputation. He served Ontario Hydro for 47 years and retired as Chief Engineer in 1960, having been involved in almost all of the major hydro-electric developments in Ontario. On his death, Mr. Holden left a sum of money which was later augmented by his widow, the late Florence Holden, to establish a scholarship in the Faculty of Applied

Science and Engineering. This scholarship, which has a value of approximately $900 is awarded to the student who, completing the Fourth Year in Civil Engineering or Mechanical Engineering with Honours, obtains the highest aggregate marks in hydraulic engineering subjects in the Third and Fourth Years of the course. The first award was made in the session 1967–68.

ONTARIO STUDENT ASSISTANCE PROGRAM

All students who are attending eligible post-secondary institutions in Ontario may qualify for assistance under this program provided that they satisfy the residence requirements as outlined in the Ontario Student Assistance brochure and demonstrate financial need. Information and application forms may be obtained from the office of Student Awards, University of Toronto, and other post-secondary institutions, as early as June annually.

THE ONTARIO HOCKEY ASSOCIATION WAR MEMORIAL SCHOLARSHIP

The Ontario Hockey Association War Memorial Scholarship, the gift of the Ontario Hockey Association, is to be awarded annually at the Grade XIII examination to an applicant whose father served overseas with the Canadian Forces in World War I or II.

The value of this scholarship is $100 in cash, with an allowance of the same amount on the tuition fee for each session.

In determining the award of the scholarship, the academic qualifications of the candidate shall be first taken into account, provided always that no candidate shall be eligible for an award who has not met all the conditions required by the University of candidates for admission scholarships generally; but coeteris paribus, the award shall be made to a student who is in proved need of assistance.

The award shall be made by the Governing Council of the University upon the report of a Committee to be appointed, upon which Committee there shall be always one member of the Staff of the University who shall be deemed to be representative of the Association.

Application should be made to the Office of Student Awards on the regular scholarship application form in April.

PAULIN MEMORIAL SCHOLARSHIP

The Paulin Memorial Scholarship, provided through the generosity of the late Mr. Fred W. Paulin, a graduate of this Faculty in 1907, was established in memory of his brother, John Cameron Paulin, a student of this Faculty, who was fatally injured in 1906 during a football practice. The scholarship, which has the value of the income from a capital fund of $10,000, approximately $550 annually, is awarded to a student who obtains high standing in the work of the First Year in the Faculty of Applied Science and Engineering.

PROCTER AND GAMBLE BURSARY PLAN

Procter and Gamble Bursaries, the gift of the Procter and Gamble Company of Canada, are awarded annually to students in all years. Applicants must have at least Second Class

Honours or better in the final examinations of the preceding year and demonstrate financial need. Applications must be submitted to the Office of Student Awards on or before November 15.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO ADMISSION SCHOLARSHIP.

The Ontario Professional Engineers Foundation for Education provides an admission scholarship of the value of $500. It is awarded to the candidate who obtains the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to the Council that his attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other Admission scholarship.

Application must be made to the Office of Student Awards in April, on the regular admission scholarship application form.

ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO SCHOLARSHIPS

The Ontario Professional Engineers Foundation for Education offers scholarships of a value of $250 in each of the First, Second and Third Years in the Faculty of Applied Science and Engineering in any course, to the students who, taking Honours, obtain the highest standing in the work of their respective years.

These scholarships will not be awarded to students who hold other scholarships.

PROFESSIONAL ENGINEERS GOLD MEDAL

The Association of Professional Engineers of the Province of Ontario has established in the Faculty of Applied Science and Engineering an award in the form of a gold medal accompanied by a gift of technical books of an approximate value of $50. The award will be made to the student of the final undergraduate year in any program who, taking honours, obtains the highest weighted average percentage in the practical work and written examinations of the year.

RANSOM SCHOLARSHIP IN CHEMICAL ENGINEERING

The Ransom Scholarship in Chemical Engineering was established by A. C. Ransom, Esq., of Toronto, for the purpose of encouraging and giving financial assistance to students who choose the field of Chemical Engineering. This donation, consisting of

$5,000, provides for a perpetual scholarship of an annual amount such as will be derived from the income of this sum. The first award was made on results of the annual examinations of 1938.

The scholarship will be awarded annually to the student registered in the course in Chemical Engineering who obtains the highest aggregate percentage of marks in the examinations of the First Year. The scholarship will be paid to the winner only if he proceeds to take his Second Year in the course in Chemical Engineering in the University of Toronto.

J. E. REID MEMORIAL PRIZE

This prize, established in 1967 in memory of the late Professor J. E. Reid, is awarded to the student in the Fourth Year of the program in Electrical Engineering who, graduating with honours, achieves the highest aggregate marks in the Fourth Year examinations in the subjects pertaining to electronic communication.

THE RHODES SCHOLARSHIPS

The Rhodes Trustees offer for award in the Province of Ontario two out of ten of the Rhodes Scholarships for Canadians, each of the value of £1,000 and tenable at Oxford University for a period of two years; in certain cases, a third year may be authorized.

Each candidate must be a British subject with at least five years domicile in Canada and be unmarried; he must have passed his nineteenth but not twenty-fifth birthday on October 1 of the year for which he is elected; he must have completed the first year of his course at a Canadian University at the time of application.

A candidate may apply either for the province in which he has his private home or residence, or for the province in which he has taken his university course.

In that section of the will in which he defined the general type of scholar he desired, Mr. Rhodes mentioned four groups of qualities, the first of which he considered most important.

(1) Literary and scholastic attainments;
(2) Qualities of manhood, truth, courage, devotion to duty, sympathy, kindliness, unselfishness, and fellowship;
(3) Exhibition of moral force of character and of instincts to lead and to take an interest in his fellows;
(4) Physical vigour, as shown by fondness for and success in outdoor sports.

Some definite quality of distinction, whether in intellect, character or personality, or in any combination of these, is the most important requirement. Financial need does not receive special consideration.

Forms of application and full information regarding these scholarships may be obtained from the Director, Office of Student Awards, University of Toronto, or from Arthur R. A. Scace, Esq., General Secretary for the Rhodes Scholarships in Canada, Box 48, Toronto

Dominion Centre, Toronto. Selection is made in December for the following year and all applications must reach the provincial secretary before November 15 annually.

R.C.E. MEMORIAL SCHOLARSHIP

The Memorial Fund Committee of the Royal Canadian Engineers has established the R.C.E. Memorial Scholarship of a value of $125, open to students who have successfully completed their second to last year in the Faculty of Applied Science and Engineering or the School of Architecture.

A Candidate must be:

(*a*) a member in good standing of the Canadian Officers Training Corps and have successfully completed one summer season's training, or

(*b*) an ex-member of the Canadian Officers Training Corps who has successfully completed two years of C.O.T.C. Training and has transferred to the Canadian Army (Militia) or to the Canadian Army (Supplemental Reserve), or

(*c*) a member of the Canadian Army (Regular) attending University under the Regular Officers Training Plan.

Selection is made on the basis of academic standing and of qualities of leadership.

Application forms may be obtained from the Office of Student Awards.

REGULAR OFFICER TRAINING PLAN

Tenable in approved degree courses, this plan is available to Canadian citizens who undertake to serve in the armed forces for at least four years after graduation. Accepted candidates will receive tuition, a book allowance of $125 and a living allowance of $240 per month during the academic session.

Application should be made to the Canadian Forces Recruiting Centre, 25 St. Clair Avenue West, Toronto.

HELEN E. ROGERS ADMISSION SCHOLARSHIPS

Admission scholarships have been established from a bequest from the estate of Helen E. Rogers open to students entering any degree course in the University. Preference is given to applicants from outside Ontario but failing such candidates, awards may be made to qualified Ontario students. Recipients must have a standing satisfactory to the Committee of Award on first admission and may continue to enjoy the scholarship in the upper years provided they maintain first class standing. The value in each year is a minimum of $200 and a maximum of $1,500 dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards in April on the regular admission scholarship application form.

DON SALT MEMORIAL SCHOLARSHIPS

In memory of Donald John Salt, a graduate of the Faculty of Applied Science and Engineering and a practising geophysicist, the Canadian Exploration Geophysical Society has provided two scholarships of the value of $500 which are open to students in the Third and Fourth Years of certain courses in the Faculty of Arts and Science, and in Geological Engineering and the Geophysics option of Engineering Science in the Faculty of Applied Science and Engineering.

The award is made on evidence of the interest and ability of the applicant in relation to the field of mining geophysics.

Application should be made either to the Chairman of the Department of Physics or the Chairman of the Department of Geology and Applied Earth Science by March 1 in the calendar year in which the award is to be made.

ROSEDALE CHAPTER I.O.D.E. AWARD IN ENGINEERING SCIENCE

An award of $400 will be made annually to a student enrolled in the Third Year of the program in Engineering Science, on the basis of academic standing and financial need. Recipients must be Canadian citizens, but not necessarily residents of Ontario.

Application should be made to the Secretary of the Faculty on the regular in-course bursary application form not later than November 15.

FREDERICK W. SCHUMACHER SCHOLARSHIP

The Frederick W. Schumacher Scholarship has been established in the Faculty of Applied Science and Engineering and in the Faculty of Arts under a bequest of the late Frederick W. Schumacher. It has a value of the income from the fund. The scholar must (*a*) be enrolled in the Second, Third or Fourth Years in Geological Engineering in the Faculty of Applied Science and Engineering or in Physics and Geology or Geological Sciences in the Faculty of Arts and (*b*) must have high academic standing.

Applications must be submitted to the Office of Student Awards not later than November 15.

"SECOND MILE ENGINEER" AWARD

The Class of 3T5, convinced that a successful engineer must not only be professionally competent but also constantly aware of his responsibilities to humanity, and inspired by an address of President William E. Wickenden of the Case School of Applied Science, Cleveland, called "The Second Mile," which was based on the text from the Sermon on the Mount, "whosoever shall compel thee to go one mile, go with him twain", has established the "Second Mile Engineer" award. It is the desire of the donors to encourage undergraduates to participate fully in extra-curricular activities and to recognize the true importance of the more liberal subjects of the curriculum with the ultimate objective, on

entering the profession, of becoming worthy Second Mile Engineers. The award comprises a grant of $200, a suitably inscribed presentation piece and an illuminated scroll, and is presented to a student in his final year.

An eligible group is chosen from those who have taken a prominent part in the affairs of the Faculty, either as office holders or in athletics. In making the award, consideration is given to academic standing, with special emphasis on the candidate's attainments in the cultural and humanistic-social studies.

Particulars are furnished each session by the Class of 1935.

THE SIMPSONS-SEARS LIMITED (NORTHERN ONTARIO) SCHOLARSHIPS

These scholarships, the gift of Simpsons-Sears Limited, are open only to students of the Copper Cliff High School, the Sudbury High and Technical Schools, the Sturgeon Falls High School, the North Bay Collegiate Institute and Vocational School, the Kapuskasing High School and all the Secondary Schools along the Ontario Northland Railway. A scholarship of the value of $100 is available for each of the schools mentioned and an additional sum of $50 will be given to the student who obtains the highest percentage of Grade XIII subjects selected in accordance with the regulations.

No scholarship will be awarded unless the candidate is in actual attendance in one of the colleges or faculties of the University and maintains a uniformly high standard to the satisfaction of the donors of scholarships.

Application for these scholarships must be sent not later than May 15, to the Principal, Algonquin Composite School, North Bay, from whom further information may be obtained regarding conditions of award.

WALLACE AWARD
SOCIETY OF AUTOMOTIVE ENGINEERS PRIZE

In memory of William Wallace, Professor of Mechanical Engineering, University of Toronto, the Ontario Society of Automotive Engineers offers an annual prize of the value of $100 to a student of the Fourth Year in any course whose thesis on a topic related to Automotive Engineering is considered by the Chairman of the Department of Mechanical Engineering to be of suitable quality and the most satisfactory.

SOCIETY OF CHEMICAL INDUSTRY MERIT AWARD

The Society of Chemical Industry Merit Award is made annually by the Society to the student in Fourth Year in the Department of Chemical Engineering who obtains the highest weighted average of marks in the results of the annual examinations for the year. The award is a gold key.

THE MURRAY F. SOUTHCOTE SCHOLARSHIP

Established by friends of the late Murray F. Southcote, a graduate of this Faculty (Aeronautical Engineering, 1950) this scholarship, which has a value of $100, is awarded

in recognition of high standing at the Annual Examinations of the Third Year, in any course in the Faculty.

The first award was made in the Session 1964–65.

WALTER STERLING ADMISSION SCHOLARSHIPS

Established in memory of Walter Sterling, these scholarships are open to students entering any first degree course at the University of Toronto. Recipients must obtain First Class Honours standing on the Ontario Grade XIII papers required for admission and may continue to enjoy the scholarships in each year of their course providing they maintain Honour standing. The value of the scholarship is from $200 to $1,500 annually, dependent on financial need. The number of awards made each year is determined by the annual income available.

Application should be made to the Office of Student Awards on the regular scholarship application form. The statement of financial need should be completed if an award greater than $200 is desired.

C. H. E. STEWART BURSARIES

Under the provisions of the will of the late Mary Jones Stewart a sum of $10,000 was bequeathed to the University, the income of which is to be used to provide a number of bursaries in denominations of $50, $75 and $100 to students in the Third and Fourth Years of courses in the Faculty of Applied Science and Engineering, the awards to be made on the basis of financial need, scholastic ability and general character, with preference being given to students who are descendants of veterans of the First and Second World Wars. Applications should be submitted to the Secretary of the Faculty by November 15, on the regular in-course bursary application form.

EDITH TYRRELL MEMORIAL BURSARY

The Women's Association of the Mining Industry of Canada has presented this Bursary, having the value of $600, annually, commencing in 1939, and named in memory of their founder and president, Mrs. Edith Tyrrell. A medal donated by Dr. Tyrrell accompanies this Bursary. The Bursary is awarded to a student entering the Third or Fourth Year in the course of Metallurgy and Materials Science, or Geological Engineering; it may be awarded two years in succession to the same student, but will usually be awarded at the beginning of the Third Year. The award will be made by a special Committee appointed by the association on the following basis:

(*a*) In addition to mental capacity, the student must show leadership ability and give promise, through his activities, of becoming a worthwhile influence in the affairs of the profession and the community.

(*b*) While attention is given to scholastic ability, as evidenced by his academic standing, it is not the governing factor. He must, however, stand in the top quarter of his class.

(*c*) Special consideration is given to financial need.

Application must be made to the Secretary of the Faculty within one month of the opening of the academic year.

S. UBUKATA FUND

The S. Ubukata Fund for Japanese students was established to assist students from Japan proper to pursue a course of study at the University of Toronto. The fund provides grants of varying values on the basis of the information submitted by the applicants who:
(*a*) must be Japanese students from Japan proper;
(*b*) must register in the University of Toronto devoting full time to their studies;
(*c*) are able to satisfy admission requirements regarding English facility;
(*d*) are not holding other financial aid.

UNIVERSITY OF TORONTO ALUMNI ASSOCIATION WAR MEMORIAL SCHOLARSHIPS

Six scholarships are awarded by the University of Toronto Alumni Association to students entering first degree courses at the University of Toronto. The scholarships have a value of $500 annually, and are tenable for two years, providing satsifactory academic standing is maintained. They are awarded for general proficiency in Grade XIII, and in addition to academic performance the Committee of Award will take into consideration the candidate's relationship to active service in the Armed Forces of Canada, need of financial assistance, participation in extra-curricular activities and such other qualifications as may commend themselves to the Committee. One scholarship will be available to a student whose home is not in the Province of Ontario.

Students resident in Ontario may apply on the general admission scholarship form which must be submitted to the Office of Student Awards not later than May 1. Evidence of relationship to active service in the Armed Forces of Canada should be attached. Students resident outside Ontario may obtain the necessary forms from the Office of Student Awards, University of Toronto.

WALLBERG ADMISSION SCHOLARSHIPS

Six admission scholarships, each of a value of $1,000 are awarded annually from the income from the Wallberg Bequest on the recommendation of the Council of the Faculty to the six candidates who obtain the highest average percentage in the subjects of Grade XIII prescribed for admission to the Faculty of Applied Science and Engineering. In order to qualify for the scholarship a candidate must at one Scholarship examination obtain an average of at least 75% in the subjects of Grade XIII prescribed for admission to the Faculty and must register in the Faculty of Applied Science and Engineering. The Scholarship will not be awarded to a student who has spent more than one year in Grade XIII or more than five years in a Secondary School or its equivalent unless he can show evidence satisfactory to Council that this attendance has been extended beyond the period specified for reasons beyond his control. This scholarship is not tenable with any other admission scholarship.

Applications must be submitted to the Office of Student Awards in April on the regular admission scholarship application form.

WALLBERG UNDERGRADUATE SCHOLARSHIPS

These scholarships, four in number, of the value of $500 each, derived from the Wallberg Bequest, are awarded annually: two to students ranking first and second respectively at the annual examinations of the First Year; one to the student ranking first at annual examinations of the Second Year; and one to the student ranking first at the annual examinations of the Third Year.

Any holder of one of these scholarships may not hold other awards listed in the index with an asterisk. The awards were first made on the result of the annual examination of 1947.

PETER S. WHITE MEMORIAL BURSARY IN EARTH SCIENCES

Donated by the Texas Gulf Sulphur Company in memory of the late Peter S. White, B.A.Sc. 1956, this bursary of the value of the tuition fee plus $100, is open to students in the Faculty of Arts and Science (in Geology, Physics and Geology or Physics) and in the Faculty of Applied Science and Engineering (in the Mineral Exploration Option of Geological Engineering or the Geophysics Option of Science). The award will be made on the basis of scholastic ability and financial need. Application should be made on the regular in-course bursary form not later than November 15.

THE STEWART WILSON AWARD

This award is available through the generosity of the Engineering Alumni Association. Its value fluctuates to cover the residence fee of New College ($1,540 in 1976–77). The first award was made in 1965–66. It is open to students who, proceeding to the Second Year of any course in the Faculty of Applied Science and Engineering, were resident or non-resident members of New College during their First Year. The award is based upon academic ability, leadership qualities, contribution to New College activities and financial need. The award winner shall reside in the Stewart Wilson Room of New College during the academic year of his tenure.

Application should be made to the Registrar of New College by March 31, and announcements regarding a successful candidate will be made by August 1.

W. S. WILSON MEDALS

These medals have been provided in recognition of the service to the Faculty of Applied Science and Engineering of its former Assistant Dean and Secretary, William Stewart Wilson.

A medal will be awarded to the student in each graduating course, who, attaining Honours, achieves the highest standing in the final year of his course.

The first awards were made in the Session 1962–63.

WILLIAM R. WORTHINGTON MEMORIAL SCHOLARSHIP

The William R. Worthington Memorial Scholarship, the gift of Miss Ida R. Worthington, in memory of her brother William R. Worthington, DIPL. (1904), B.A.Sc. (1905), of the value of the income from the fund, is awarded annually to the student of the Second Year in the course in Civil Engineering who ranks highest at the annual examinations of that year.

The first award was made at the examination for the Session 1954–55.

LOAN FUNDS

From the loan funds mentioned below, small loans can be made to students who are in urgent need of assistance. The funds are not large and the loans must accordingly be restricted, both in amount and number, and principally to students in the Third and Fourth Years.

Inquiries for loans from any of the following funds should be made at the Office of the Secretary of the Faculty.

Engineering Society Loan Fund
James W. Crocker Memorial Fund
Harry F. Bennett Educational Fund
S. A. E.-Canadian Section Loan Fund
Avro Aircraft Limited Engineering Loan Fund
The William Storrie Memorial Fund
3T6 Engineers Loan Association
4T0 Engineering Loan Fund
The Devonshire Loan Fund
Class of '09 Trust Fund
University of Toronto Alumni Loan Fund
Wallberg Memorial Loan Fund

CLASS OF 1936 LOAN ASSOCIATION

Members of the Class of 1936 have made arrangements to assist students in obtaining loans through regular banking facilities. Information may be obtained from the Secretary of the Faculty.

ENGINEERING SOCIETY LOAN FUND

In 1932 the Engineering Society repaid to the Board of Governors a series of annual grants which, over a period of years, had been made to the Society for special purposes. The Board of Governors, appreciating this action, set aside this sum, to be known as the Engineering Society Loan Fund, to provide loans to students of the Faculty of Applied Science and Engineering. The administration of the fund is carried out by a Committee

appointed by the Governing Council. The fund is not large, and only small loans can be made to relatively few students. Further inquiries should be made at the Office of the Secretary of the Faculty.

JAMES W. CROCKER MEMORIAL LOAN FUND

This fund was established by Mrs. William Crocker in memory of her son, James W. Crocker, a graduate in Mining Engineering in 1938, who was killed in an accident in a mine in the same year.

HARRY F. BENNETT EDUCATIONAL FUND

This fund was established by subscription from members of the Engineering Institute of Canada in memory of the late Harry F. Bennett. M.E.I.C., who for six years prior to his death in 1946 was chairman of the Institute's Committee on the Training and Welfare of the Young Engineer, and who accomplished so much in this field by untiring efforts.

One purpose of the fund is to make loans to deserving students who need financial assistance to enable them to study Engineering Science at University level, and who have proved themselves by successfully completing their First Year in Engineering or the equivalent.

Loans will be made largely on the basis of character and to men who seem likely to develop the high professional standards which are essential to leadership in Engineering Science. A student who has been aided by this fund should feel that high obligations are placed on him; obligations to the subscribers, to the trustees, and to those coming after him who in turn can receive help as his loan is repaid.

Application forms may be obtained at the Faculty Office. The regulations are simple and the application of any worthwhile student will be given immediate and careful attention.

SOCIETY OF THE AUTOMOTIVE ENGINEERS – CANADIAN SECTION LOAN FUND

The Society of Automotive Engineers – Canadian Section has established a loan fund of $1,200 in the Faculty of Applied Science and Engineering. Preference is given to students in good scholastic standing and engaged in studies relative to the automotive and aircraft industries, and to students in Fourth, Third and Second years in that order. Particulars may be obtained from the Secretary of the Faculty.

AVRO AIRCRAFT LIMITED ENGINEERING LOAN FUND

Avro Aircraft has established a loan fund of $3,000 to provide loans to Engineering students requiring financial assistance. Application should be made to the Secretary of the Faculty.

THE WILLIAM STORRIE MEMORIAL FUND

The William Storrie Memorial Fund has been established by Mrs. William Storrie to provide loans to undergraduates in the course in Civil Engineering. Application should be made to the Secretary of the Faculty.

THE DEVONSHIRE LOAN FUND

This fund has been established by Graduates and friends of Devonshire House to assist students in the Residence.Application should be made to the Office of the Dean of Devonshire House.

CLASS OF '09 TRUST FUND

The Class of '09 on the 50th Anniversary of their graduation made a sum of money available in the Faculty for financial aid to undergraduates, with preference to Second Year students. Inquiry should be made to the Secretary of the Faculty.

THE UNIVERSITY OF TORONTO ALUMNI LOAN FUND

This fund comes from subscriptions received originally in 1919 and in succeeding years from graduates of the University and is administered by the University of Toronto Alumni Association.

Loans are available to undergraduate and graduate students enrolled in a full time course at the University, in Second and subsequent years. Funds are available for emergency purposes only.

Particulars may be obtained from The University of Toronto Alumni Association, Alumni House, Willcocks Street, Toronto.

IX Fees and Expenses

FEES

1. Undergraduate students in the Faculty of Applied Science and Engineering must pay annual fees according to the schedule listed below.

Payment may be made in two or more instalments, with a minimum first instalment as shown. If payment by instalments is elected, a service charge of 1½% per month compounded from September 15 is applied to the outstanding balance.

Students will receive by mail in August a fees form and instructions for the payment of fees. In order to avoid delay in registration at the opening of the session, it is recommended that at least the first instalment of fees be forwarded by return mail before August 15.

Fees must be paid by certified cheque or money order payable to the University of Toronto in Canadian funds, and mailed to the Office of the Comptroller, University of Toronto, Toronto M5S 1A2.

2. Payment of at least the first instalment must be made before the opening day of the session. A registration card cannot be issued until the student has complied with this requirement.

3. The remainder of the tuition fee, if not already paid, is due on January 15, without further notice. All fees for the session must have been paid in full before the student can be admitted to the annual examinations.

4. Fees, residence dues and other charges set forth in this calendar are subject to change by the Governing Council. The attention of visa students is drawn to the statement at the end of this section.

SCHEDULE OF FEES (FULL-TIME STUDENTS)

Academic Year	Academic Fee[1]	Incidental Fees[2]	Total Fee (if paid in one instalment)	Minimum First Instalment
I-IV (Men)	$850	$95.50	$945.50	$605.50
I-IV (Women)	$850	$85.50	$935.50	$595.50

1.The Academic Fee includes the following fees: Tuition; Library and Laboratory Supply; Annual Examinations; Laboratory Fees; and Degree.

2.These Incidental Fees include the following fees: Hart House; Students' Administrative Council; Athletic; Health Service; Engineering Society; Faculty Athletic Association.

PART LOAD STUDENTS

For each engineering course - $80.00
Incidental Fee - $7.00, payable once annually.

SPECIAL STUDENTS

For each engineering course - $120
Incidental Fee - $7.00, payable once annually.

FEE FOR RE-CHECKING MARKS

A student who requests that his marks be re-checked must submit with his request a fee of five dollars ($5) for each paper to be checked. The fee is refunded if an error is found.

FEE FOR TRANSCRIPTS

Transcripts of academic record are furnished by the Faculty Office on payment of a fee of $1.50 for a single copy plus 50 cents for each additional copy requested on the same order. Transcripts will not be issued without pre-payment. No charge is made for transcripts directed to other faculties or departments within the University of Toronto.

PENALTY FOR LATE REGISTRATION

Any student who registers after the last date for normal registration must petition for acceptance of his registration and is required to pay a late registration fee as follows:

If registering within 7 calendar days-$10
If registering after 7 calendar days-$20

PENALTY FOR LATE SUBMISSION OF PROGRAM DOCUMENTS

A student who fails to submit his program documents (e.g pre-registration, course selection or examination application forms) by the prescribed date will be subject to a fine of $1 for each day beyond the deadline to a maximum of $20.

SUMMARY OF STUDENTS' EXPENSES

The following approximate statement of expenses will give the student a general idea of the cost of obtaining an education in the Faculty of Applied Science and Engineering in the University of Toronto, exclusive of personal expenses:

1. Fees, see schedule on preceding page.
2. Board and lodging, per week.....$40 up
3. Books and instruments, per year.....$200 up

STUDENTS ENTERING ON STUDENT VISAS

There is a likelihood of an increase in tuition fees for students on student visas who commence an engineering program in the session 1977-78 or later. The Government of Ontario has recommended an increase to $750 per term ($1500 per year at the University of Toronto) for such students at all Ontario Universities. The University of Toronto has not yet decided its policy on this matter, but it may be that the fees of these students will be set at the level requested by the government.

EVALUATION AND PROMOTION

I. DEFINITIONS

1. The academic program consists of a consecutive sequence of sessions. There are two sessions per academic year, the winter session and the summer session. The winter session has two terms, the Fall term and the Spring term. The evaluation and promotion of students is based upon their performance in the two terms of the winter session. With permission of the responsible division or department, courses may be taken in the summer session, and the results of these courses may exempt the student from an equivalent requirement in a subsequent winter session term. The evaluation period for the purpose of promotion is a single winter term. This calendar states the dates upon which the terms begin and end.

2. The notation 1F, 1S, 2F, 2S, ... is used to represent the first winter session fall term, first winter session spring term, second winter session fall term, second winter session spring term, etc.

3. Term Average.

   (a) Fall Term average

   The fall term average is calculated on the basis of all Fall Term courses in which the student is enrolled at the beginning of the eighth week of the term, with the weighting factor for each course being the weight units assigned to it. Mid-year results of full-year courses will not be included in the calculation of the Fall Term average.

   (b) Spring Term average

   The Spring term average is calculated on the basis of all courses in which the student is enrolled at the beginning of the eighth week of the term with the weighting factor for each course being the weight units assigned to it. The results of full-year courses will be included in the Spring term average with a weight equal to the sum of the Fall and Spring term weights.

(c) Penalties for late withdrawal

A student who withdraws from a course after the beginning of the eighth week cf the term, or who does not complete the ccurse or write the final examination will receive a failing mark in the course based on his earned term mark as a fraction of 100. This mark will be included in the calculation of his term average.

A student who in any term withdraws from the Faculty after the deadline specified in the calendar is deemed to have failed the term.

4. Core Courses.

A core course is defined as any course in a program that is sc designated by a department or division.

5. Course Grades.

The correspondence between course marks and course grades and between weighted term average marks and weighted term average grades is as fcllcws:

Percentages	Grade
90 - 100	A+
85 - 89	A
80 - 84	A-
77 - 79	B+
73 - 76	B
70 - 72	B-
67 - 69	C+
63 - 66	C
60 - 62	C-
57 - 59	D+
53 - 56	D
50 - 52	D-
35 - 49	E
0 - 34	F

6. Incomplete Courses.

Notwithstanding the mark obtained by a student in a course, the examiner may report the grade as "Incomplete" if some part of the ccurse work has not been performed. Upon confirmation of the incomplete status by the Committee on Examinations, the student will be required to complete the course work to the satisfaction of the examiner before the end of the subsequent term.

7. Honour Standing.

(a) Hcnour standing, in the work of a term, is granted, if the term is not being repeated and if the weighted term average grade is A- (80%) or better.

(b) Hcnour graduate standing will be granted to students who obtain honour standing in both terms 4F and 4S and in two of terms 2F, 2S, 3F or 3S.

8. Checking of Marks.

It is the policy of the Faculty that no examination papers or essays will be re-read or re-evaluated after the results have been issued. All results are carefully reviewed before being released. However, the clerical work involved in the examining department and in the Faculty Office will be checked upon written request to the Secretary of the

Faculty of Applied Science and Engineering. Any such request must be submitted within three months of the date of the examination. The request must be accompanied by a fee of $5 for each paper to be checked. The fee will be refunded if an error is found.

9. Penalties for Lateness.
Due dates, manner of submission, and penalties for failure to comply are normally prescribed by staff members for all work to be submitted by students for credit in any course. This includes, inter alia, problem sets, essays, laboratory reports, design reports, drawings and theses. Suitable notification of such due dates and penalties is provided, for example, by posted notices or in instruction sheets distributed at scheduled classes.

II. PROMOTION REGULATIONS

1. Tabular Form.
The regulations for promotion and failure are shown in tabular form in Section III.

2. Degree Requirements.
To qualify for a degree, a student must complete a full undergraduate program, as shown in the Faculty calendar.

A full undergraduate program consists of eight terms taken in order in four or more winter sessions. In order to gain credit for a term a student must

(a) satisfy the academic regulations to proceed to the suceeding term as described herein, and

(b) not be subsequently required to repeat the term for which credit is to be gained, and

(c) achieve a course grade of E or better in every course taken as part of the academic load in the term (see Regulation II-9), and

(d) not have a grade of "Incomplete" outstanding for any course in the term (see Regulation I-6).

3. Final Term.
To be eligible to graduate, a student must attain a weighted term average grade of C- or better in his final term. If a student does not attain a weighted term average of C- or better in the final term, and he is placed on probation with permission to proceed to the next term on first or second probation, he must repeat the final term (see Regulation II-4(c) below) on first or second probation, and achieve a weighted term average grade of C- or better in order to graduate (see Regulation II-5 below).

4. Academic Credit.
(a) The normal academic load is 72 units per term. A student in second or higher years may, with the approval of his departmental chairman, reduce his load to not less than approximately 60 units, or, in exceptional cases, increase it to not more than approximately 84 units. Any such permission to reduce the load

taken in any term does not relieve the student of the requirement to obtain credit for all the courses of that term in order to graduate. First year students may not reduce their loads.

(b) Students who, in a summer session or any winter term, are given Faculty permission to take courses whose total weight is less than the minimum normal academic load (60 units) are known as part-load students. A part-load student will not be granted term credit for the term in which he is on part-load. If part-load permission is granted, and if the student achieves a course grade of C- or better in any courses of the part-load term, the student will be exempted from the equivalent course requirement in his regular full-time program. Students who have been required to withdraw for a specified number of terms, or students who have failed and must repeat a term, will not normally be granted part-load permission prior to re-enrollment as full-time students.

(c) Students who are repeating a term must repeat the term exactly as it is described in the Calendar applicable at the time of repetition. In a term which is being repeated, no credit is retained for courses previously taken in which a course grade lower than B- was achieved. Courses in which a course grade of B- or better has previously been achieved need not be repeated. Students may enroll in a course not yet taken rather than repeating a course in which a course grade of B- or better has been achieved. If a student achieves a course grade of C- or better in the substituted course, he will be exempted, on application, from the equivalent course requirement in his regular full-time program. Students who are repeating a term may choose different elective courses from those that they chose before. Exemption from future course requirements based on electives taken in a failed term and replaced with other electives in a repetition of the term will not be granted.

5. Repetition.

Students are not normally permitted to repeat a term more than once. Regardless of the status shown in the Regulations for Promotion and Failure of Section III, a student whose tabulated status would otherwise permit him to repeat a term for a second or subsequent time will be given the status "Failed - required to withdraw. See Evaluation and Promotion Regulations II-6."

6. Re-enrollment After Withdrawal.

(a) A student who has been required to withdraw may apply at any time for a decision on his eligibility to re-enroll. Re-enrollment is not automatic, and if permitted, may not take place until the specified period of withdrawal has elapsed. Students making such application must present arguments to justify a resumption of their studies. Such application should be made with the advice of the chairman of the responsible department or division or, in the case of students re-applying for First year, with the advice of the Secretary of the Faculty.

Students who have not achieved a weighted term average grade of C- or better in at least one term in the Faculty and who have withdrawn or have been required to withdraw have no standing in the Faculty and must apply for re-admission to the University.

A student who has been required to withdraw a second time will not be re-enrolled.

(b) Students who are permitted to re-enroll after having been required to withdraw will, in general, be required to resume their studies in the term corresponding to that which succeeds the term in which they last achieved a weighted term average grade of C- or better. In no case will such re-enrollment be permitted in a term corresponding to one which is a successor of the term specified above. In some cases, because of curriculum changes, the possible withdrawal or alteration of programs etc., the Faculty may require that such students re-enroll in a term corresponding to one which precedes that specified above, and re-commence their studies from that term with no credit being given for any work previously done in a corresponding term or terms. Students who have been required to withdraw, and are subsequently permitted to re-enroll, will be re-enrolled on first probation if their previous record is clear, and otherwise on second probation.

7. Mid-Course Withdrawal.
Students who have failed or been required to withdraw must discontinue their studies as soon as they are notified of this requirement. This applies whether or not the student is enrolled in courses which continue in the following term. In all cases where a continuing course is dropped, the student will not receive credit for any work already done in the course.

8. Admission on Probation.
New students may, in certain circumstances, be admitted to the first term or other term of an Engineering program on a first or second probation. The regulations for promotion and failure which apply to such students are the standard regulations for promotion and failure for students on first or second probation. Students will not be admitted to the Engineering Science program on probation in any term.

9. Credit for Courses.
(a) Students whose course grade is F in any course taken as a part of the academic load in a term will not be given credit for that course. Required courses in which a grade of F is achieved must be repeated, and elective courses must be repeated or replaced with courses of comparable level with the approval of the responsible department or division. See Regulation II-2.

(b) Only one repetition or replacement of a course as described in section (a) above will normally be permitted. If credit is not obtained for the original course on repetition, or for the replacing course, the student will be required to withdraw (see Regulation II-6).

10. English Facility Requirement.
Every student is required to demonstrate appropriate facility in written English on a test administered after admission to the Faculty. Failure to demonstrate the required facility at that time must be remedied by appropriate action (possibly including non-credit courses for which a fee may be charged) and the required facility demonstrated in subsequent testing. This facility must be demonstrated before the student will be allowed to proceed to his final year of studies.

III REGULATIONS FOR PROMOTION AND FAILURE

The regulations for promotion and failure are given below in tabular form. There are two important parameters to these regulations, the student's previous record and the weighted term average (WA) achieved by the student in the current term. The regulations are presented in five sections, according to the student's previous record. The first section applies to First Year students with a clear record.

FIRST YEAR STUDENTS WITH A CLEAR RECORD

Engineering Programs

Term 1F

60≤WA	Passed - proceed to next term with a clear record.
50≤WA<60	Placed on first probation - proceed to next term on first probation.
WA<50	Failed - required to withdraw for at least three winter terms. See Evaluation and Promotion Regulation II-6.

Term 1S

Term 1S regulations are the same as the regulations for "ALL OTHER STUDENTS". See the appropriate section following.

Engineering Science Program

Term 1F

60≤WA	Passed - proceed to next term with a clear record.
50≤WA<60	Passed - proceed to next term in another program with a clear record.
WA<50	Failed - required to withdraw for at least three winter terms. Not eligible to continue in Engineering Science. See Evaluation and Promotion Regulation II-6.

Term 1S

66≤WA	Passed - proceed to next term with a clear record.
55≤WA<66	Passed - proceed to next term in another program with a clear record.
50≤WA<55	Placed on first probation - proceed to next term in another program on first probation.
WA<50	Failed - may re-enroll in the corresponding term the second time it is next offered on first probation. Not eligible to continue in Engineering Science. See Evaluation and Promotion Regulation II-6.

ALL OTHER STUDENTS

Students With A Clear Record

For first year regulations see the previous table. These regulations apply to all students with a clear record, other than those in Term 1F of an Engineering program, and other than those in first year of the Engineering Science program.

60≤WA	Passed - proceed to the next term with a clear record.
55≤WA<60	Placed on first probation - proceed to next term on first probation.
50≤WA<55	Failed - may re-enroll in the corresponding term on first probation the next time it is offered.
WA<50	Failed - may re-enroll in the corresponding term on first probation the second time it is next offered.

Students On First Probation

60≤WA	Passed - proceed to next term with a cleared first probation.
55≤WA<60	Failed to clear first probation - may re-enroll on second probation in the term in which the first probation was acquired the next time it is offered.
50≤WA<55	Failed while on first probation - required to withdraw for at least two winter terms. See Evaluation and Promotion Regulations II-6.
WA<50	Failed while on first probation - required to withdraw for at least six winter terms. See Evaluation and Promotion Regulations II-6.

Students With a Cleared First Probation

60≤WA	Passed - proceed to next term with a cleared first probation.
55≤WA<60	Placed on second probation - proceed to the next term on second probation.
50≤WA<55	Failed - may re-enroll in the corresponding term on second probation the next time it is offered.
WA<50	Failed - required to withdraw for at least three winter terms. See Evaluation and Promotion Regulations II-6.

Students On Second Probation

60≤WA — Passed while on second probation - proceed to next term on second probation.

WA<60 — Failed while on second probation - required to withdraw for at least six winter terms. See Evaluation and Promotion Regulations II-6.

IV. GRADING STANDARDS

The University has approved a uniform statement of the meaning of the letter grades used to report performance in courses. The grades assigned for courses of the Faculty of Applied Science and Engineering conform to that statement, which follows:

A letter grade of A indicates an exceptional performance with strong evidence of original thinking, good organization, capacity to analyze and synthesize; a superior grasp of the subject matter with sound critical evaluations; evidence of an extensive knowledge base.

A letter grade of B indicates a good performance with evidence of a grasp of the subject matter, some evidence of critical capacity and analytic ability, and reasonable understanding of the relevant issues under examination; evidence of familiarity with the literature.

A letter grade of C indicates an intellectually adequate performance of a student who is profiting from his/her university experience; an understanding of the subject matter and an ability to develop solutions to simple problems found in the material.

A letter grade of D indicates a minimally acceptable performance; some evidence of familiarity with the subject matter and some evidence that critical and analytic skills have been developed.

A letter of grade of E indicates an inadequate performance in the subject; evidence of familiarity with only some of the subject matter; the presence of some critical and analytic skills.

A letter grade of F indicates an inadequate performance in which there is little evidence of even a superficial understanding of the subject matter; in which there is weakness in critical and analytic skills, with limited or irrelevant use of literature.

V TRANSFER OF PROGRAM

1. Transfers within the Faculty:

A student may be permitted to transfer from one program to another within the Faculty of Applied Science and Engineering, subject to the following conditions and exceptions. Application to transfer must be made on a Request for Transfer Form available at the Faculty Office.

(a) Transfers at any level are subject to the availability of places, except that students who have satisfied the requirements for promotion in Engineering Science at the end of Term 1F or 1S may transfer to any other program within the Faculty without restriction.

(b) A student in Term 1F in Engineering Science may apply for immediate transfer to an Engineering program up to the last date for adding or substituting Fall Term courses. Thereafter he may not apply to transfer until the end of Term 1F or Term 1S.

(c) Applications of First Year students to transfer from one Engineering program to another will be considered at the end of Term 1S when the number of available places in each second year program is known. In the case where the number of applicants exceeds the number of places available in a program, selection will be made during the period April 15 to June 30.

(d) Transfers from Engineering programs to Engineering Science are not permitted except in extraordinary cases.

(e) Transfers after the beginning of the Second Year will normally involve curriculum adjustments to remedy deficiencies.

2. Transfers to other Faculties:

A student interested in transferring to another Faculty or School in the University of Toronto should consult with the Secretary of the Faculty or School concerned in regard to the feasibility of transferring.

GENERAL REGULATIONS

I ATTENDANCE

1. Students proceeding to the degree are required to attend the courses of instruction and the examinations in all subjects prescribed. A student whose attendance or work is deemed by the Council of the Faculty to be unsatisfactory may have his registration cancelled at any time.

2. Students must conform to all lecture room and laboratory regulations. Reports, briefs, theses and drawings become the property of the Council to dispose of as it may see fit. Drawings, briefs and field notes will not be accepted unless they have been made at the time and place provided in the time table.

II PETITIONS AND APPEALS

1. A student who is unavoidably absent at any time during the term, and consequently misses any graded work, should submit a Petition for Consideration in Course Work. Such petitions must be accompanied by appropriate documentation (e.g., medical certificate) and must be submitted to the Faculty Office within one week of the student's return to classes.

2. A student who believes that his academic performance has been adversely affected by illness, mishap or other circumstance during the term or the examination period should submit a Petition for Leniency. Such petitions must be submitted to the Faculty Office within one week of the date of the student's last examination.

3. A student may petition with respect to the applicability to him of any academic regulation of the Faculty. The petition must show the grounds on which the student believes that the regulation should be waived or altered in his case. The student should consult his departmental counsellor before submitting such a petition to the Faculty Office.

4. A student wishing to appeal against a decision with respect to any petition should submit his appeal in written form to the Faculty Ombudsman Committee via the Secretary of the Faculty. The Committee, which is composed of two members of the teaching staff and two students, with the Speaker of Faculty Council as chairman, will consider the appeal, and, on request of the student, will hear him in person. Should the Committee so decide, it will undertake to intercede with the appropriate authority on behalf of the student. The Committee does not have authority to alter any decision itself, but uses informal means to have the decision altered. Should the Ombudsman Committee be dissatisfied with the result of an informal approach, it may take the matter to the Faculty Council for final decision. A decision by the Ombudsman Committee not to intercede further, or a decision by Faculty Council on an appeal brought to it by the Ombudsman Committee, is the final decision of the Faculty.

5. A student wishing to appeal against a final decision of the Faculty may appeal to the Governing Council of the University. In that event, he should consult the Secretary of the Faculty or the Secretary, Sub-Committee on Academic Appeals, Office of the Governing Council, about the preparation and submission of his appeal.

6. The University Ombudsman investigates grievances or complaints against the University, or anyone in the University exercising authority, from any member of the University - student, faculty or admistrative staff. He assists in any way he can in resolving grievances or complaints, and can recommend changes in academic or administrative decisions where this seems justified. In handling a grievance or complaint, he has access to all relevant files and information, and to all appropriate University officials.

The Ombudsman also provides information to members of the University about their rights and responsibilities, and the procedures to follow in order to pursue whatever business or complaint they may have. All matters dealt with by the Ombudsman are handled in a strictly confidential manner unless the individual involved approves otherwise. The Ombudsman is independent of all administrative structures of the University, and is accountable only to the President and the Governing Council.

For information, advice or assistance, contact the office of the Unversity Ombudsman, University of Toronto, 16 Hart House Circle, Toronto, Ontario M5S 1A1 (Telephone 978-4874.)

III EXTRA-CURRICULAR ACTIVITIES AND ACADEMIC CREDIT

It is in general desirable for students to engage to a reasonable extent in extra curricular activities in order that they may not become too narrowly professional in interest and outlook, but it will be obvious that no academic credit can be given for such activities.

Some offices in student organizations require quite large amounts of time for the proper performance of the duties connected with them. Some athletic activities, such as being a member of a varsity team, also make large demands on time, and also may result in conflicts between examinations or term tests, and scheduled games. Students on probation or with marginal academic records should not undertake such activities and will not be given any special consideration for such activities in the evaluation or scheduling of academic work, including the final examinations in December or April.

IV DISCIPLINE

(a) Academic

The Governing Council of the University of Toronto has approved a Code of Behaviour regarding academic discipline applying to all students and members of the teaching staff of the University. This Code describes the rights and freedoms to be enjoyed by members of the University. It also lists forms of behaviour regarded as academic offences in the University, and the sanctions for such offences. Examples of such offences include plagiarism, cheating in examinations, the evaluation of a student's work by irrelevant criteria, etc. Such offences may be referred to the University Disciplinary Tribunal and to other relevant disciplinary bodies in the University.

The full text of the Code of Behaviour and the Governing Council Enactment concerning the Disciplinary Tribunal can be obtained from college and faculty offices, the office of the Vice-President and Provost, the office of the Secretary of the Governing Council, and that of the Chairman of the University Disciplinary Tribunal.

(b) Discipline in non-academic matters

The Councils of University College, Scarborough, Erindale, New and Innis Colleges, the governing bodies of the Federated Universities and Affiliated Colleges, and the Councils of the Faculties, Schools and Institutes have disciplinary jurisdiction over the conduct of all students registered in these divisions of the University in all matters of local or internal concern to the divisions. Jurisdiction over the conduct of students while in residence rests with the body administering the residence.

Where the appropriate body exercising disciplinary jurisdiction has found that a student of the University has engaged in conduct prejudicial to the interests of the University, the Caput may, in its discretion, suspend or expel such student from the academic privileges of the University. Every decision of the Caput involving the expulsion of a student from the University, requires confirmation of the Governing Council. The role of

Caput and the various Councils as described above is contingent on the understanding that offences or actions or claims within the jurisdiction of criminal and civil courts will be referred where appropriate to those courts and will only be reviewed by the Caput where the implications to the University are considered sufficiently important to warrant such review.

V CAMPUS ORGANIZATIONS

Responsibilities for recognition of organizations where the membership is drawn from a single College, Faculty or School rests with the Council of that division. Where campus-wide organizations (or organizations drawing members from more than one division or constituency of the University) are concerned, responsibility is vested in the Internal Affairs Committee of the Governing Council.

Eligibility for recognition is assessed annually. The constitutions of every society or association, and subsequent amendments to such constitutions, shall be submitted to the appropriate adminstrative officer for perusal. The objectives and activities of groups seeking recognition should be seen as attempting to contribute to the educational, recreational, social or cultural values of the University. Membership in groups should be open to all members of the University community without restriction on the grounds of national origin, race, religion, colour, or sex. Status as non-voting members may be extended to interested persons from outside the University.

XI Program Specifications and Course Outlines

The curriculum is based upon a term system in which all courses of instruction (with the exception of certain courses taken in the Faculty of Arts and Science) are one term in duration. There are two terms in the annual session, each concluding with final examinations in the courses offered. Students are evaluated for promotion at the end of each term.

The curriculum provides a good deal of latitude to the student in choosing his program of study. A regular program normally consists of a maximum of six courses per term with a total weight of 72 units; with the approval of the Chairman of his Department a student enrolled in the second or higher years may elect to reduce his load to a minimum of 60 units per term, or to increase it to a maximum of 84 units per term.

On the following pages of this section the curriculum of each program is set forth in detail. A common curriculum for students in First Year (in First and Second Years in Engineering Science) forms a basis in the fundamental subjects prior to subsequent specialization in various Engineering disciplines. The student is able to choose from a wide range of technical electives in the senior years, and in the Fourth Year, all programs contain a thesis, which provides the student with the opportunity to carry out original work in his chosen field of study.

As a guide to students in apportioning their time, a weight factor is associated with each course of instruction offered in the University. For courses taught by or for this Faculty, the weight is shown opposite the course listing on the following pages. For courses selected from other faculties, for example as Free Electives, the weight is specified by the offering Faculty. This weight factor is used in the computation of the student's weighted average in the work of the term.

The programs and regulations contained in this Calendar hold good for this academic year only, and the Faculty of Applied Science and Engineering does not bind itself to adhere for the whole period of a student's attendance to the conditions here laid down. The Faculty reserves the right to withdraw any course for which there is insufficient enrollment or resources, and to limit the enrollment in any course.

ELECTIVE COURSES

Elective courses fall into four categories, viz. Technical Electives; Non-Technical Electives (in First and Second Year); Open Electives (in Third Year) and Free Electives (in Fourth Year). In general, the student must not select elective courses which would involve excessive duplication of material covered elsewhere in his program. As the promotional evaluation

of engineering students is based on a weighted term average, courses for which a final mark expressed as a percentage is not available (e.g. pass/fail courses) may not be taken as electives. The following paragraphs provide further instructions on the selection of elective courses:

1. TECHNICAL ELECTIVES: These are specified in the prescription for the program in which the student is registered. In most cases the choice is restricted to a specified list of available Technical Electives. The availability of a particular elective course may depend on a sufficient number of students wishing to take it; in a few courses it may be necessary to limit the number of students enrolled.

2. NON-TECHNICAL ELECTIVES (First and Second Year): Each student must include a Non-Technical Elective in each term of his First Year program and in one term of his Second Year program. In general, acceptable Non-Technical Electives have as their central theme the study of man as an individual or of man as a social being. Courses that are not acceptable are those that have an appreciable mathematical, skills, or technical content.

The following courses have been arranged specifically for students of the Faculty of Applied Science and Engineering, and have been scheduled on Monday, Wednesday and Friday at 1, so as to be availble to all students. The work load in these courses is compatible with the student's work load in Engineering courses.

Eng281F/S	Effective Writing
ENG282F/S	Twentieth Century Literature I
ENG283F/S	Canadian Literature I
ENG284F/S	Varieties of Fiction I
ENG285F/S	Drama and the Modern Theatre I
ENG286F/S	Literature and Science I
ENG292S	Twentieth Century Literature II
ENG293S	Canadian Literature II
ENG294S	Varieties of Fiction II
ENG295S	Drama and the Modern Theatre II
ENG296S	Literature and Science II
HPS280F	History of Science
HPS281F	History of Technology and Engineering up to the Industrial Revolution
HPS282S	History of Technology and Engineering from the Industrial Revolution to the Present
HPS283S	Technology, Engineering and Society
HPS480S	Seminar on the Evolution of Technology
PHL291F	Science and Society
PHL292S	Science and Philosophy

Students desiring a broader choice in their Non-Technical Electives may obtain from the Faculty Office or their Departmental Offices, information concerning courses offered by the Faculty of Arts and Science and other faculties and schools in the University which are acceptable as Non-Technical Electives. These courses encompass a broad range, including languages, history, philosophy, anthropology, psychology, economics, political science, etc. Students are cautioned that some of these courses may require a larger commitment of time than those courses which have been arranged specifically for the Faculty of Applied Science and Engineering.

3. OPEN ELECTIVES (Third Year only): In each term of the Third Year there is provision for an Open Elective which the student must fill. Courses

acceptable as Open Electives are (i) any course which is acceptable as a Non-Technical Elective as defined above, or (ii) excluding courses offered by or for the Faculty of Applied Science and Engineering, any degree credit course listed in a current calendar of the University of Toronto, its constituent colleges, federated colleges, or federated universities.

A student in the Third Year whose technical program involves 24 or more units per term taken outside the Faculty may be permitted to choose a course offered within the Faculty as his Open Elective.

4. FREE ELECTIVES (Fourth Year only): In each term of the Fourth Year there is provision for a Free Elective which the student must fill. Any degree credit course listed in a current calendar of the University of Toronto, its constituent colleges, federated colleges, or federated universities is acceptable as a Free Elective, subject to approval of enrollment by the teaching department offering the course. If taken within the Faculty of Applied Science and Engineering, the Free Elective must be a course carrying a weight of at least 9 units per term.

Note: The weights shown in the following program listings for non-specific course selections, e.g., Free Elective, Non-Technical Elective etc., are shown as guides only. In all cases the course weight used for marks averaging is that weight specified by the Faculty offering the course.

PROGRAM AND COURSE APPROVALS

Students must obtain the approval of their program department for their course selection and, in selecting elective courses, must also conform to any enrollment requirements set by the department offering the course.

FIRST YEAR CURRICULUM--ENGINEERING

Civil Engineering
Geological Engineering and Applied Earth Science
Mechanical Engineering
Industrial Engineering
Chemical Engineering
Electrical Engineering
Metallurgy and Materials Science

Term 1F		Lect.	Lab.	Tut.	Wt.
Applied Mechanics	CIV100F	3	-	2	15
Calculus I	MAT186F	2	-	2	9
Algebra I	MAT188F	2	-	2	9
Non-Technical Elective*					12
and one of:					
Computer Programming+	APS100F/S	1	-	3	10
Computer Programming+	APS101F/S	1	-	3	10
Engineering Graphics+	CIV135F/S	2	5	-	12
and one of:					
Chemistry	CHE111F	3	3	1	18
Chemistry	CHE112F	3	3	1	18
Chemistry	CHE113F	3	3	1	18
Term 1S					
Electricity and Magnetism	ELE121S	3	1	1	15
Calculus II	MAT187S	2	-	2	10
Algebra II	MAT189S	2	-	2	10
Non-Technical Elective*					12
and one of:					
Computer Programming+	APS100F/S	1	-	3	10
Computer Programming+	APS101F/S	1	-	3	10
Engineering Graphics+	CIV135F/S	2	5	-	12
%and one of:					
Engineering Design	CED101S	2	1	1.5	12
Chemical Engineering Projects**	CHE101S				12
Applied Physical Geology	GLG180S	3	1.5	-	12
Introduction to Metals	MMS100S	3	1.5	-	12
Introduction to Thermal Physics and Waves	PHY182S	3	1.5	-	12

+One half of the students in Engineering will take Computer Programming in Term 1F; the other half will take Engineering Graphics. The arrangement is reversed in Term 1S.

*Students will select one Non-Technical Elective course each term as described previously in this section.

%None of these Technical Electives shall be pre-requisite for any course given in a subsequent term. Any elective in which there is insufficient enrollment may be withdrawn.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7.5 hours of laboratory weekly.

FIRST YEAR CURRICULUM--ENGINEERING SCIENCE

Term 1F		Lect.	Lab.	Tut.	Wt.
Mechanics (Statics)	CIV101F	2	-	1	9
Chemistry#	CHE150F	3	3	1	15
Introduction to Computer Programming	CSC180F	2	2	-	12
Calculus I	MAT194F	3	-	2	12
Elements of Physics I (Mechanics)	PHY180F	2	1.5	1	12
Non-Technical Elective*					12
Term 1S					
Electricity and Magnetism	ELE150S	3	-	1	12
Linear Algebra	MAT185S	3	-	1	12
Calculus II	MAT195S	3	-	1	12
Elements of Physics II (Thermodynamics and Statistical Physics)	PHY181S	2	1.5	1	12
Non-Technical Elective*					12
%and one of:					
Engineering Design	CED101S	2	1.5	1	12
Chemical Engineering Projects**	CHE101S				12
Engineering Graphics	CIV136S	2	-	2.5	12
Applied Physical Geology	GLG180S	3	1.5	-	12
Introduction to Metals	MMS100S	3	1.5	-	12

#Students who have not had Grade 13 Chemistry or the equivalent may petition for permission to substitute CHE 111F for CHE 150F.

*Students will select one Non-Technical Elective course each term as described previously in this section.

%None of these Technical Electives shall be pre-requisite for any course given in a subsequent term. Any elective in which there is insufficient enrollment may be withdrawn.

**Students select three projects from a provided list, for which the contact times may vary from 3 hours of lectures to 7.5 hours of laboratory weekly.

SECOND YEAR CIVIL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Engineering Materials	CIV209F	4	2	1	14
Strength of Materials	CIV210F	3	-	2	12
Surveying	CIV255F	3	2	1	13
Computer Programming	CIV260F	2	-	2	11
Calculus	MAT280F	3	-	2	13
Non-Technical Elective					12
Term 2S					
Structures I	CIV211S	4	-	2	15
Environmental Systems	CIV240S	2	1	-	9
Civil Engineering Projects	CIV267S	2	2	2	12
Probability and Statistics	CIV271S	3	-	2	12
Practical Experience	APS299Y	-	-	-	-
Geology* or	GLG280S	2	1.5	1	12
Basic Science Course					
Economics for Engineers	ECO281S	3	-	1	12

*Students who have taken GLG180S in First Year must replace GLG280S by a basic science course, normally PHY282S.

THIRD YEAR CIVIL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Structures II	CIV312F	3	-	2	12
Soil Mechanics	CIV321F	3	1	-	11
Transportation Systems	CIV330F	3	-	2	12
Survey Camp*	CIV358F	-	-	-	12
Engineering Mathematics	CIV370F	3	-	2	12
Fluid Mechanics	MEC351F	3	1.5	-	12
Open Elective					12
Term 3S					
Structures III	CIV313S	3	-	2	12
Foundations	CIV322S	2	-	2	10
Municipal and Hydraulic Engineering	CIV340S	3	1.5	2	15
Engineering Economics and Decision Making	CIV375S	3	-	2	12
Technical Elective**		3	-	2	12
Open Elective					12

*Survey Camp is taken prior to the commencement of regular courses in Third Year and the results included with those for the subsequent term on the basis of a weighting of 12 units.

**For list of Technical Electives, see following Fourth Year.

FOURTH YEAR CIVIL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Civil Engineering Systems	CIV468F	3	-	2	12
Technical Elective**		3	-	2	12
Technical Elective		3	-	2	12
Technical Elective		3	-	2	12
Technical Elective		3	-	2	12
Free Elective					12
Term 4S					
Public Speaking	CIV474S	-	-	2	4
Thesis	CIV499S	-	6	-	18
Technical Elective		3	-	2	12
Technical Elective		3	-	2	12
Technical Elective		3	-	2	12
Free Elective					12

**Technical Electives. During Third and Fourth Year, students select eight Technical Electives. Each student is advised to consult with a member of the staff in establishing the electives in his program. The Technical Electives offered by the Department of Civil Engineering are given below. Courses offered outside the department may be taken, with the approval of the Chairman of the Department.

Fall Term Electives

CIV416F	Reinforced Concrete I
CIV419F	Indeterminate Structures
CIV420F	Construction Engineering
CIV421F	Foundations and Earthwork
CIV479F	Special Studies in Civil Engineering
CIV498F	Thesis+
CIV505F	Advanced Strength of Materials
CIV524F	Rock Mechanics
CIV529F	Air Photo Interpretation
CIV530F	Traffic Engineering
CIV531F	Transportation Planning
CIV540F	Water and Pollution Control Engineering
CIV550F	Water Resources and Hydrology

+With the permission of the Chairman of the Department, a student may elect to undertake a 30-unit thesis by taking both CIV498F and CIV499S.

Spring Term Electives

CIV338S	*Urban and Regional Planning Techniques
CIV413S	*Modular Construction
CIV414S	*Advanced Engineering Materials
CIV417S	Reinforced Concrete II
CIV422S	*Engineering Geology
CIV432S	Highway Engineering
CIV456S	*Engineering Applications of Surveying
CIV475S	Adminstration and Management
CIV479S	Special Studies in Civil Engineering
CIV518S	Behaviour and Design of Steel Structures
CIV541S	Air Pollution Control Engineering
MEC452S	Hydraulic Engineering

*Available to Third and Fourth Year students.

SECOND YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

Term 2F		Lect.	Lab.	Tut.	Wt.
Strength of Materials	CIV210F	3	-	2	12
Topics in Geological Engineering	GLE201F	2	-	2	10
Introductory Mineralogy and Petrology	GLG220Y	2	3	-	12
Calculus	MAT293F	2	-	2	12
Economics for Engineers	ECO281F	3	-	1	12
and one of:					
Principles of Physical Geology*	GLG140F	2	2	1	12
Basic Classical and Modern Physics**	PHY283F	3	-	-	12
Term 2S					
Probability and Statistics	STA282S	2	-	2	12
Principles of Historical Geology	GLG141S	2	2	1	12
Introductory Mineralogy and Petrology	GLG220Y	2	3	-	12
Calculus and Differential Equations	MAT294S	2	-	2	12
Mineral Chemistry	MMS226S	3	-	1	12
Non-Technical Elective					12
Field Trip†	GLG325F				
Practical Experience††	APS299Y				

*This course is required of students who have not taken GLG 180S.

**PHY 283F is recommended preparation for PHY 338Y taken in IV year, Option A. Students who do not take PHY 283F in II year should take it as an open elective in III Year.

†Field Trip, GLG325F, must be taken by all students in Geological Engineering and Applied Earth Science. This is an 8 day field trip immediately following term 2S examinations. Results for the camp will be included with those of the third year fall term on a basis of 6 units. A fee, currently about $100.00, is charged to cover part of the cost of transportation and accomodation.

††Students are reminded that the practical experience requirements, see course outlines, must be completed before graduation.

THIRD YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

OPTION A (Mineral Exploration)

		Lect.	Lab.	Tut.	Wt.
Term 3F					
Field Trip	GLG325F	-	-	-	12
Planning and Management of Mineral Exploration I	GLE301F	3	-	1	12
Petrology	GLG320Y	2	3	-	12
Stratigraphy and Sedimentation	GLG321F	1	3	-	12
Phase Diagrams for Geologists	GLG330F	3	-	-	12
Geometry and Kinematics of Tectonic Structures	GLG332F	1	3	-	12
Open Elective					12
Term 3S					
Planning and Management of Mineral Exploration II	GLE302S	3	-	1	12
Petrology	GLG320Y	2	3	-	12
Principles of Precambrian Geology	GLG327S	2	2	-	12
Introduction to Geochemistry	GLG331S	3	-	-	12
Analysis of Tectonic Structures	GLG333S	1	3	-	12
Open Elective					12
Field Camp*	GLG425F				

*Students in Option A must attend Field Camp, GLG 425F. This is a 14 day field camp immediately following Term 3S examinations. Results for the field camp will be included with those of the subsequent term on a basis of 12 units. A fee, currently about $100.00, is charged to cover part of the cost of food and accommodation.

OPTION B (Mineral Engineering)

		Lect.	Lab.	Tut.	Wt.
Term 3F					
Field Trip	GLG325F	-	-	-	12
Fluid Mechanics and Heat Transfer I	CHE305F	2	-	1	8
Mass Transfer Operations I	CHE310F	2	-	2	10
Planning and Management of Mineral Exploration I	GLE301F	3	-	1	12
Mineral Identification Laboratory	GLG372H	-	2	-	6
Mineral Processing I	MMS301F	2	3	1	12
Minerals Equilibria	MMS309F	3	-	2	12
Open Elective					12
Term 3S					
Numerical Analysis	CCS382S	2	-	1.5	12
Planning and Management of Mineral Exploration II	GLE302S	3	-	1	12
Mineral Identification Laboratory	GLG372H	-	2	-	6
Metallurgical Analytical Chemistry Lab.	MMS228S	-	3	-	5
Extractive Metallurgy I	MMS305S	3	3	1	14
Surface Properties of Materials	MMS311S	2	-	1	10
Open Elective					12
Field Trip*					

*As part of their MMS courses, students in Option B are required to attend a series of field trips to metallurgical and mining operations during their third and fourth years. Approximately 3 to 5 days of trips are planned for each session. The cost to each student is currently about $50.00 per session. Arrangements for the trips are made by the Department of Metallurgy and Material Science.

OPTION C, (Geotechnical Engineering)

Term 3F		Lect.	Lab.	Tut.	Wt.
Field Trip	GLG325F	-	-	-	12
Soil Mechanics	CIV321F	3	1	-	11
Engineering Mathematics	CIV370F	3	-	2	12
Stratigraphy and Sedimentation	GLG321F	1	3	-	12
Geometry and Kinematics of Tectonic Structures	GLG332F	1	3	-	12
Glacial and Periglacial Geology	GLG326F	2	3	-	12
Fluid Mechanics	MEC351F	3	1.5	-	12
Term 3S					
Foundations	CIV322S	2	-	2	10
Structural Design	CIV314S	2	-	3	12
Engineering Economics and Decision Making	CIV375S	3	-	2	12
Analysis of Tectonic Structures	GLG333S	1	3	-	12
Open Elective					12
Open Elective					12
Field Camp*	GLG416F				

*Student in Option C must attend Field Camp, GLG 416F. Results for the field camp will be included with those of the subsequent term on a basis of 12 units. This is a 14 day camp held immediately following Term 3S examinations. The first week is in the Toronto area and will include field observation and practice in geotechnical engineering. The second week is on instruction and experience in geological mapping. A fee, currently about $60.00, is charged to cover part of the cost of food and accommodation for the second week.

FOURTH YEAR GEOLOGICAL ENGINEERING AND APPLIED EARTH SCIENCE

OPTION A (Mineral Exploration)

Term 4F		Lect.	Lab.	Tut.	Wt.
Field Camp	GLG425F	-	-	-	12
Economics of Mineral Resources	GLE401F	3	-	1	12
Mineral Deposits	GLG421Y	2	3	-	12
Exploration Geochemistry	GLG480Y	2	3	-	12
Petroleum Geology and Energy Resources	GLG428F	2	3	-	12
Exploration Geophysics	PHY338Y	2	-	-	12
Geophysics Laboratory I	PHY324H	-	3	-	6
Free Elective					12
Term 4S					
Mineral Deposits	GLG421Y	2	3	-	12
Exploration Geochemistry	GLG480Y	2	3	-	12
Thesis	GLE492S	-	6	-	12
Exploration Geophysics	PHY338Y	2	-	-	12
Geophysics Laboratory I	PHY324H	-	3	-	6
Free Elective					12

OPTION B (Mineral Engineering)

Term 4F		Lect.	Lab.	Tut.	Wt.
Economics of Mineral Resources	GLE401F	3	-	1	12
Thesis	GLE493Y	-	4	-	8
Ore Mineral Identification Lab.	GLG481Y	-	3	-	5
Extractive Metallurgy II	MMS401F	3	1.5	2	13
Mineral Process Design	MMS414F	1	3	1	10
Free Elective					12
and one of:					
Electro-Chemical and Kinetic Processes	MMS302F	2	-	4	12
Electrical Systems	ELE470F	3	3	-	13
Term 4S					
Environmental Engineering	CHE423S	2	-	1	10
Thesis	GLE493Y	-	6	-	12
Ore Mineral Identification Lab.	GLG481Y	-	3	-	5
Metallurgical Operations Analysis	MMS407S	2	-	2	10
Mineral Processing II	MMS412S	2	1.5	-	10
Pilot Plant Operations	MMS405S	-	-	-	4
Free Elective					12
and one of					
Advanced Chemical Metallurgy	MMS406S	2	-	1	10
Advanced Iron and Steel Making	MMS420S	3	-	-	10

OPTION C (Geotechnical Engineering)

Term 4F		Lect.	Lab.	Tut.	Wt.
Field Camp	GLG416F	-	-	-	12
Foundations and Earthwork	CIV421F	3	-	2	12
Rock Mechanics	CIV524F	3	-	2	12
Subsurface Exploration	CIV525F	3	-	2	12
Air Photo Interpretation	CIV529F	3	2	-	12
Free Elective					12
and one of:					
Construction Engineering	CIV420F	3	-	2	12
Thesis*	GLE495Y	-	6	-	12
Term 4S					
Engineering Geology Seminars	CIV423S	3	-	2	12
Groundwater	CIV549S	2	-	3	12
Design of Earth and Rock Structures	CIV428S	2	-	3	12
Thesis	GLE495Y	-	6	-	12
or	GLE496S	-	6	-	12
Free Elective					12
and one of:					
Environmental Systems	CIV240S	2	1	-	9
Administration and Management	CIV475S	3	-	2	12
Hydraulic Engineering	MEC452S	3	2	-	12

*With the permission of the Chairman of the Division a student may elect to undertake a 24 - unit thesis.

SECOND YEAR MECHANICAL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Circuit Theory and Measurements	ELE270F	3	1.5	1.5	12
Calculus	MAT293F	2	-	2	12
Mechanics of Solids I	MEC211F	3	1.5	1.5	12
Differential Equations	MEC261F	3	-	3	12
Basic Science Elective*					12
Non-technical Elective					12
Term 2S					
Electromechanical Energy Conversion	ELE272S	2	1.5	1.5	12
Dynamics I	MEC201S	3	-	1.5	12
Mechanics of Solids II	MEC212S	3	-	1.5	12
Metrology	MEC265S	2	1.5	1.5	12
Materials Science	MMS223S	3	1.5	-	12
Economics for Engineers	ECO281S	3	-	1	12

*A student must include a Basic Science Course in his programme which would normally be a course in fundamental physics. Some acceptable courses are:

PHY 215F Geophysics
PHY 282F Introduction to Modern Physics
PHY 283F Basic Classical and Modern Physics

THIRD YEAR MECHANICAL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Thermodynamics I	MEC321F	3	1.5	1.5	15
Fluid Mechanics I	MEC341F	3	1.5	1.5	15
Engineering Analysis I	MEC362F	3	-	3	15
Analysis and Design of Mechanisms	MEC371F	3	-	3	15
Open Elective					12
Term 3S					
Numerical Methods	CSC382S	2	-	1.5	12
Vibrations	MEC303S	3	1	2	12
Thermal Energy Conversion	MEC322S	3	3	-	12
Engineering Analysis II	MEC363S	2	-	1.5	12
Open Elective					12
Technical Elective (one of group I)		3	1.5	1.5	12

FOURTH YEAR MECHANICAL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Mechanics of Solids III	MEC413F	2	-	1.5	12
Heat Transfer	MEC431F	3	1.5	1.5	12
Control Systems I	MEC455F	3	1.5	1.5	12
Free Elective					12
Technical Elective (one of group II)		2	1.5	1.5	
Thesis	MEC499Y	-	-	-	12
or					
Design Project	CED401Y	-	2	3	12
Term 4S					
Applied Fluid Mechanics	MEC443S	3	3	-	12
Design	MEC472S	2	-	3	12
Free Elective					12
Technical Elective (one of group I)		3	1.5	1.5	12
Technical Elective (one of group III)		2	1.5	1.5	
Thesis	MEC499Y	-	-	-	12
or					
Design Project	CED401Y	-	2	3	12

Technical Electives

Group I (offered in 3S and 4S)

Thermal Environment Engineering**	MEC324S
Analysis of Machining Processes**	MEC375S
Analysis of Forming Processes***	MEC376S
Biomechanical Engineering***	MEC381S

**To be offered alternate years; available 1978/79
***To be offered alternate years; available 1977/78

Group II

Introduction to Nuclear Engineering	CHE427F
Instrumentation Design	ELE471F
Dynamics II	MEC1001F
Thermodynamics II	MEC1101F
Fluid Mechanics II	MEC1201F
Principles of Measurement	MEC1050F

Group III

Direct Energy Conversion	MEC427S
Environmental Pollution and Control	MEC444S
Control Systems II	MEC1303S

SECOND YEAR INDUSTRIAL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Introduction to Industrial Engineering I	IND201F	2	-	2	12
Computers and Programming I	IND202F	2	-	2	12
Calculus	MAT293F	2	-	2	12
Probability	STA291F	2	-	2	12
Materials Science and Engineering	MMS222F	2	1.5	1	12
Economics for Engineers	ECO281F	3	-	1	12
Term 2S					
Introduction to Industrial Engineering II	IND200S	2	-	2	12
Computers and Programming II	IND203S	2	-	2	12
Calculus and Differential Equations	MAT294S	2	-	2	12
Statistics	STA292S	2	-	2	12
Non-Technical Elective					12
and one of:					
Mechanics of Materials	CIV205S	2	3	-	12
Electrical Engineering	ELE271S	3	1.5	1	12
Other Technical Elective					

THIRD YEAR INDUSTRIAL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Accounting I	COM390F	2	-	-	12
Numerical Methods	CSC381F	2	-	2	12
Operational Research I	IND301F	1	-	2	12
Applied Statistical Analysis	IND306F	2	-	2	12
Utilization of Energy	IND308F	2	-	2	12
Open Elective					12
Term 3S					
Operational Research II	IND302S	2	-	2	12
Human Factors in Man-Machine Systems	IND305S	2	3	-	12
Fundamentals of Production	IND307S	2	-	2	12
Control Engineering	MEC357S	2	1	1	12
Technical Elective*					
Open Elective					12

*Technical Electives arranged and scheduled by the Department are:

Differential Equations	APM391F	2	-	2	12
Industrial Relations	IND304S	2	-	1	12
Accounting II	COM391S	2	-	-	12

FOURTH YEAR INDUSTRIAL ENGINEERING

		Lect.	Lab.	Tut.	Wt.
Term 4F					
Free Elective*					12
Thesis	IND499Y	-	6	-	12
and four of: (%)					
Differential Equations	APM391F	2	-	2	12
Fundamentals of Management Science	IND413F	2	-	1.5	12
Production Systems	IND415F	2	-	1.5	12
Stochastic Models	IND417F	2	-	1.5	12
System Simulation	IND418F	2	-	1.5	12
Management Information Systems	IND421F	2	-	1.5	12
Human Information Processing in Man-Machine Systems	IND424F	2	3	-	12
Other Technical Elective*					
Term 4S					
Free Elective*					12
Thesis	IND499Y	-	6	-	12
and four of: (%)					
Applications of Management Science	IND414S	2	-	1.5	12
Scheduling and Control	IND416S	2	-	1.5	12
Information and Optimization	IND419S	2	-	1.5	12
Mathematical Programming	IND420S	2	-	1.5	12
Human Performance in Man-Machine Systems	IND423S	2	3	-	12
Dynamics of General Systems	IND425S	2	-	1.5	12
Organizational Theory□	IND412S	2	1	-	12
Other Technical Elective*□					

*The electives listed with the Third Year also qualify as Other Technical or Free Electives in Fourth Year.

□When Organizational Theory is chosen as a Technical, rather than a Free elective, then the Other Technical Elective in that term is restricted to courses offered within the Faculty of Applied Science and Engineering.

%At least three elective in each of terms 4F and 4S must be IND400-level courses.

Students are reminded that all their course selections in any one term, and over the entire four years, are subject to approval by the Department on their merits as a program of studies.

SECOND YEAR ENGINEERING SCIENCE

Term 2F		Lect.	Lab.	Tut.	Wt.
Differential Equations I	APM288F	3	-	-	12
Chemical Systems	CHE209F	3	3	-	12
Electric Circuits	ELE250F	3	1.5	1	12
Calculus III	MAT295F	3	-	1	12
Elements of Physics III (Fields and Waves)	PHY280F	3	1.5	1	12
Economics for Engineers	ECO281F	3	-	1	12
Term 2S					
Complex Variables	MAT289S	3	-	.5	12
Elements of Physics IV (Quantum Physics)	PHY281S	3	1.5	-	12
Probability and Statistics	STA287S	3	-	.5	12
Engineering Design	CED201S	-	-	6	12
Non-Technical Elective					12
and one of:					
Mechanics of Materials	CIV203S	2	-	3	12
Computer Languages	CSC280S	2	-	1	12
Materials Science	MMS250S	2	1.5	-	12

Students entering Third Year may elect

(a) tc enroll in one of the 8 options listed, or

(b) to select a program that does not conform to any one of the cptions.

In case (a), students may petition for meritorious substitutions on a basis of roughly equal weights, so that the modified program has approximately the same weight as the standard option. In case (b), the weight shall average approximately 72 units per term. In both cases, the selection of courses is subject to the constraints imposed by the current timetable, and by prerequisites. Courses may be chosen from among those cffered to other options in Engineering Science; from among those listed in the Faculty Calendar that are offered in programs other than Engineering Science; or, with the approval of the offering department, from among thcse offered in other Faculties, provided that the total applied science and engineering content is not reduced.

All electives and substituticns require the approval of the Divisicn.

Option 5a, Aerospace

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM388F	3	-	-	12
Mechanics	AER301F	3	-	1.5	12
Aerospace Labcratory I	AER303F	-	3	-	12
Electronic Circuits I	ELE351F	2	1.5	1	12
Open Elective					12
and one of:					
Heat Engineering	MEC327F	2	3	-	12
Quantum Mechanics	PHY383F	3	-	-	12
Other Technical Elective					
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Aerospace Laboratory II	AER304S	-	3	-	12
Aerospace Control Systems	AER306S	3	-	1.5	12
Mechanics cf Structures	AER302S	3	-	1.5	12
Fluid Mechanics	AER305S	3	-	1.5	12
Open Elective					12

Option 5c, Chemical

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM388F	3	-	-	12
Mass Transfer Operations I	CHE312F	2	-	2	12
Thermodynamics and Kinetics I	CHE303F	2	3	1	15
Introductory Organic Chemistry	CHE322F	2	3	-	12
Fluid Mechanics	MEC354F	3	1.5	1.5	12
Open Elective					12
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Thermodynamics and Kinetics II	CHE304S	2	3	-	14
Mass Transfer Operations II	CHE313S	2	-	2	12
Chemical Engineering Problems and Laboratory	CHE316S	-	3	2	10
Polymer Chemistry	CHE317S	3	-	-	12
Open Elective					12

Option 5cs, Computer Science

Term 3F					
Differential Equations II	APM388F	3	-	-	12
Physical Electronics I	ELE350F	2	.75	1	10
Electronic Circuits I	ELE351F	2	1.5	1	12
Computer Organization	ELE353F	3	1.5	1	15
System and Signal Analysis I	ELE355F	3	-	1	12
Open Elective					12
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Analysis of Man-Machine Systems	IND323S	2	2	-	11
Electronic Circuits II	ELE354S	3	3	-	14
Introduction to the Theory of Computation	CSC364S	2	-	1	12
System Software I	CSC380S	2	6	-	15
Open Elective					12

Option 5e, Electrical

Term 3F					
Differential Equations II	APM388F	3	-	-	12
Physical Electronics I	ELE350F	2	.75	1	10
Electronic Circuits I	ELE351F	2	1.5	1	12
System and Signal Analysis I	ELE355F	3	-	1	12
Electromagnetic Fields	ELE357F	3	1.5	1	14
Open Elective					12
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Physical Electronics II	ELE352S	2	.75	1	10
Electronic Circuits II	ELE354S	3	3	-	14
System and Signal Analysis II	ELE356S	3	1.5	-	12
Open Elective					12
and one of:					
Digital Systems	ELE314S	3	1.5	-	12
Analysis of Man-Machine Systems	IND323S	2	2	-	11
Other Technical Elective					12

Option 5g, Geophysics

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM388F	3	-	-	12
Principles of Physical Geology+	GLG140F	2	2	1	12
Physics of the Earth	PHY442Y	2	-	-	12
Electromagnetic Fields	ELE357F	3	1.5	1	14
Open Elective					12
and one of:					
Mechanics	AER301F	3	-	1.5	12
Electronic Circuits I	ELE351F	2	1.5	1	12
Introductory Mineralogy and Petrology	GLG220Y	2	3	-	12
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Principles of Historical Geology	GLG141S	2	2	1	12
Physics of the Earth	PHY442Y	2	-	-	12
Elasticity and Fluid Mechanics	PHY344S	2	-	-	12
Open Elective					12
and one of:					
Transport Phenomena	MEC349S	3	1.5	1.5	12
Electronic Circuits II	ELE354S	3	3	-	14
Introductory Mineralogy & Petrology	GLG220Y	2	3	-	12

+Students with credit for GLG 180S may take two of the technical electives

Option 5m, Materials Science

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM388F	3	-	-	12
Physical Metallurgy I	MMS304F	3	3	-	12
Metallurgical Thermodynamics	MMS306F	2	-	4	12
Introduction to Solid State Physics	PHY334F	2	-	-	12
Structure of Materials	MMS333F	2	2	-	12
Open Elective					12
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Physical Metallurgy II	MMS303S	3	3	-	12
Materials Science	MMS307S	3	-	-	12
Metallurgical Chemistry	MMS312S	3	-	4	14
Open Elective					12
and one of:					
Extractive Metallurgy I	MMS305S	3	3	1	14
Surface Properties of Materials	MMS311S	2	-	1	10
Composite Materials	CHE413S	2	-	1	11
Other Technical Elective					12

Option 5nt,Nuclear and Thermal Power

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations II	APM388F	3	-	-	12
Fluid Mechanics	MEC354F	3	1.5	1.5	12
Heat Engineering	MEC327F	2	3	-	12
Quantum Mechanics	PHY383F	3	-	-	12
Introduction to Nuclear Physics	PHY335F	2	-	-	12
Open Elective					12
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Statistical Thermodynamics	MEC426S	3	1.5	-	15
Stress Analysis	MEC315S	3	-	1	12
Nuclear Reactor Fundamentals	CHE342S	3	1.5	-	12
Control Systems	MEC358S	3	1.5	1	12
Open Elective					12

Option 5p, Physics

Term 3F					
Differential Equations II	APM388F	3	-	-	12
Mechanics	AER301F	3	-	1.5	12
Electromagnetic Fields	ELE357F	3	1.5	1	14
Quantum Mechanics	PHY383F	3	-	-	12
Open Elective					12
and one of:					
Physical Electronics I	ELE350F	2	.75	1	10
Introduction to Solid State Physics	PHY334F	2	-	-	12
Introduction to Nuclear Physics	PHY335F	2	-	-	12
Term 3S					
Numerical Methods	CSC383S	2	-	1	12
Statistical Thermodynamics	MEC426S	3	1.5	-	15
Modern Physics Laboratory	PHY326S	-	6	-	12
Open Elective					12
and two of:					
Physical Electronics II	ELE352S	2	.75	1	10
Nuclear Reactor Fundamentals	CHE342S	3	1.5	-	12
Radiobiology	PHY359S	2	-	-	12
Elementary Particle Physics	PHY337S	2	-	-	12

FOURTH YEAR ENGINEERING SCIENCE

Option 5a, Aerospace

		Lect.	Lab.	Tut.	Wt.
Term 4F					
Thesis	ESC499Y	-	-	-	12
Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
and one of:					
Engineering Design I	AER406F	-	3	-	12
Aerospace Laboratory III	AER408F	-	6	-	12
and two of:					
Aerodynamics	AER401F	3	-	1.5	12
Advanced Mechanics of Structures	AER403F	2	-	1.5	12
Fundamentals of Lasers, Plasmas and Energy	AER415F	3	-	1.5	12
Term 4S					
Thesis	ESC499Y	-	-	-	12
Mathematical or Theoretical Elective [o]					12
Free Elective					12
and one of:					
Engineering Design II	AER407S	-	3	-	12
Aerospace Laboratory IV	AER409S	-	6	-	12
and two of:					
Gasdynamics	AER410S	3	-	1.5	12
Stability and Control of Aircraft	AER411S	3	-	1.5	12
Aeroelasticity	AER412S	2	-	1.5	12
Acoustic Theory and Noise Control	AER414S	2	1.5	-	12
Electronic Circuits II	ELE354S	3	3	-	14
Other Technical Elective					12

[o]Acceptable courses are listed below.

Optimization and Control Theory	APM456S	2	-	1	12
Fluid Mechanics (except 5a)	APM436S	3	-	-	12
Techniques of Optimization	ELE455S	3	-	1	12
Applied Algebra	CSC478S	2	-	1	12
Computational Methods for Partial Differential Equations	CSC446S	2	-	1	12
Probability and Applications	STA347S	3	-	-	12
Classical Mechanics (except 5a,5p)	PHY351S	3	-	-	12
Engineering Analysis IV	MEC1402S	2	-	-	12

Option 5c, Chemical

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis	ESC499Y	-	-	-	12
Rate Processes I	CHE435F	3	-	-	14
Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
and two of:					
Chemical Plant Design	CHE405F	-	-	6	11
Chemical Engineering Thermodynamics	CHE402F	2	-	1	11
Advanced Separation Processes	CHE410F	2	-	2	11
Electrochemistry and Corrosion	CHE453F	2	-	1	11
Economic Evaluation in the Process Industries	CHE456F	2	-	1	11
Strategy of Product and Process Development	CHE408F	2	3	-	11
Optimal Control of Chemical Systems	CHE537F	3	-	1.5	14
Applied Mathematics for Chemical Engineers*	CHE1107F	2	-	1	15
Other Technical Elective					12
Term 4S					
Thesis	ESC499Y	-	-	-	12
Mathematical or Theoretical Elective °					12
Rate Processes II	CHE436S	3	-	-	14
Free Elective					12
and two of:					
Environmental Engineering	CHE423S	2	-	1	11
Plastics Engineering	CHE444S	2	-	1	11
Selected Topics in Organic Chemistry	CHE434S	2	-	1	11
Modelling and Simulation of Chemical Systems	CHE440S	3	-	-	14
Chemical Reactors	CHE432S	2	-	1	11
Other Technical Elective					12

Option 5cs, Computer Science

Term 4F					
Thesis	ESC498F	-	-	-	12
Operating Systems	CSC468F	2	-	1	12
Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
and two of:					
Operational Research I	IND301F	1	-	2	12
Switching Theory	ELE405F	2	-	2	12
Communication Systems I	ELE453F	2	3	-	12

Option 5cs, Computer Science

Term 4S					
Mathematical or Theoretical Elective °					12
System Software II	CSC480S	2	6	-	15
Switching Circuits	ELE432S	2	3	-	12
Free Elective					12
and two of:					
Techniques of Optimization	ELE455S	3	-	1	12
Computational Methods for Partial Differential Equations	CSC446S	2	-	1	12
Architecture of Distributed Computer Systems	CSC458S	2	-	1	12
Applied Algebra	CSC478S	2	-	1	12
Communication Systems II	ELE454S	2	3	-	12

°Acceptable courses are listed under the program of option 5a.
*CHE1107F will satisfy the Mathematical Elective requirement in term 4S.

Option 5e, Electrical

Term 4F		Lect.	Lab.	Tut.	Wt.
Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
Select courses from the following to total approximately 72 units for the term:*					
Computer Organization	ELE353F	3	1.5	1	15
Network Theory	ELE412F	3	-	2	12
Semiconductor Electronics	ELE435F	2	1.5	1	12
Computer Software Engineering I	ELE440F	2	-	2	12
Electromagnetics	ELE420F	2	1	1	12
Electronic Circuits III	ELE452F	2	3	-	12
Communication Systems I	ELE453F	2	3	-	12
Switching Theory	ELE405F	2	-	2	12
Fundamentals of Lasers, Plasmas and Energy	AER415F	3	-	1.5	12
Power Semiconductor Circuits	ELE433F	2	3	-	12
Control Systems I	ELE410F	2	1.5	1	12
Operational Research I	IND301F	1	-	2	12
Thesis[1]	ESC499Y	-	-	-	12
Other Technical Elective					12
Term 4S					
Mathematical or Theoretical Elective[0]					8
Free Elective					8
Thesis[1]	ESC499Y	-	-	-	12
Thesis[1]	ESC498S	-	-	-	12
Select courses from the following to total approximately 72 units for the term, at least 24 units of which must be from Electrical Engineering:*					
Nuclear Instrumentation	CHE429S	2	1.5	1	12
Integrated Circuits	ELE431S	2	3	-	12
Switching Circuits[2]	ELE432S	2	3	-	12
Techniques of Optimization	ELE455S	3	-	1	12
Computer Organization	ELE441S	2	3	-	12
Biomedical Engineering[2]	ELE445S	3	1.5	-	12
Communication Systems II	ELE454S	2	3	-	12
High-Frequency Active Devices	ELE423S	2	1.5	1	12
Control Systems II	ELE411S	2	1.5	1	12
Other Technical Elective					12

[0]Acceptable courses are listed under the program of option 5a.
*Courses for which there is insufficient demand may be withdrawn.
[1]Select either ESC499Y or ESC498S, but not both.
[2]Limited enrollment
Note: the following is a partial list of other technical electives suitable for option 5e:

Power Systems Analysis	ELE413F	2	1.5	1	12
Applied Optics	ELE448F	2	1.5	1	12
Electromechanical Systems III	ELE419S	2	1.5	1	12
Radio Systems	ELE422S	2	-	1	12
Electrical and Electronic Instrumentation	ELE436S	2	3	-	12
Computer Software Engineering II	ELE442S	3	1.5	-	12

Option 5g, Geophysics

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis	ESC497Y	-	-	-	9
Theory and Application of Geophysical Methods	PHY443Y	2	-	-	12
Geophysics Laboratory	PHY324H	-	3	-	6
Geophysical Time Series Analysis Lab.	PHY422F	-	6	-	12
Geophysical Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
and one of:					
Atmospheric Physics	PHY444Y	2	-	-	12
Air Photo Interpretation	CIV529F	3	2	-	12
Planning and Management of Mineral Exploration I	GLE301F	3	-	1	12
Term 4S					
Thesis	ESC497Y	-	-	-	9
Mathematical or Theoretical Elective [o]					12
Theory and Application of Geophysical Methods	PHY443Y	2	-	-	12
Geophysics Laboratory	PHY324H	-	3	-	6
Geophysics Projects Laboratory	PHY424S	-	6	-	12
Free Elective					12
and one of:					
Atmospheric Physics	PHY444Y	2	-	-	12
Inversion Theory Laboratory	PHY423S	-	6	-	12
Planning and Management of Mineral Exploration II	GLE302S	3	-	1	12

[o]Acceptable courses are listed under the program of option 5a.

Option 5m, Materials Science

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis	ESC499Y	-	-	-	12
Solid State Science	MMS402F	3	1.5	1	12
Theory of Metallurgical Reactions	MMS410F	2	-	2	12
Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
and one of:					
Extractive Metallurgy II	MMS401F	3	1.5	2	13
Materials Engineering I	MMS432F	3	1.5	1	12
Polymer Engineering	CHE415F	2	-	1	11
Introduction to Nuclear Engineering	CHE427F	2	1.5	1.5	11
Other Technical Elective					12
Term 4S					
Thesis	ESC499Y	-	-	-	12
Mathematical or Theoretical Elective°					12
Advanced Materials Science	MMS411S	3	1.5	-	10
Advanced Chemical Metallurgy	MMS406S	2	-	1	10
Free Elective					12
and one of:					
Materials Engineering II	MMS408S	3	-	-	12
Plastics Engineering	CHE444S	2	-	1	11
Nuclear Materials	MMS416S	2	-	1	10
Advanced Iron & Steelmaking	MMS420S	3	-	-	10
Applied Physical Metallurgy	MMS417S	3	-	1	10
Other Technical Elective					12

Option 5nt, Nuclear and Thermal Power

Term 4F					
Thesis	ESC499Y	-	-	-	12
Nuclear Systems Analysis	CHE452F	2	1.5	1	12
Energy Conversion	MEC428F	3	3	-	12
Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
and one of:					
Electronic Circuits I	ELE351F	2	1.5	1	12
Introduction to Solid State Physics	PHY334F	2	-	-	12
Nuclear Physics	PHY453Y	2	1	-	12
Energy Systems Analysis	MEC429F	2	-	1	10
Term 4S					
Thesis	ESC499Y	-	-	-	12
Mathematical or Theoretical Elective°					12
Heat Transfer	MEC433S	2	-	2	12
Free Elective					12
and two of:					
Electronic Circuits II	ELE354S	3	3	-	14
Nuclear Materials	MMS416S	2	-	1	10
Nuclear Physics	PHY453Y	2	1	-	12
Radiobiology	PHY359S	2	-	-	12
Other technical Elective					12

°Acceptable courses are listed under program 5a.

Options 5p, Physics

Term 4F		Lect.	Lab.	Tut.	Wt.
Technical Elective *					12
Free Elective					12
and one of:					
Applied Functional Analysis	APM446F	3	-	-	12
Linear Algebra and Applications	MAT490F	3	-	-	12
and three of:					
Quantum Physics Laboratory	PHY425Y	-	6	-	12
Quantum Theory	PHY450Y	2	1	-	12
Statistical Mechanics	PHY451Y	2	1	-	12
Relativity Theory	PHY452Y	2	1	-	12
Nuclear Physics	PHY453Y	2	1	-	12
High Energy Physics	PHY454Y	2	1	-	12
Solid State Physics	PHY455Y	2	1	-	12
Modern Optics and Radiation	PHY456Y	2	1	-	12
Group Theory and its Physical Applications	PHY457Y	2	1	-	12
Term 4S					
Thesis	ESC498S	-	-	-	12
Applied Physics Laboratory	PHY496S	-	6	-	12
Technical Elective *					12
and three of:					
Quantum Physics Laboratory	PHY425Y	-	6	-	12
Quantum Theory	PHY450Y	2	-	-	12
Statistical Mechanics	PHY451Y	2	1	-	12
Relativity Theory	PHY452Y	2	1	-	12
Nuclear Physics	PHY453Y	2	1	-	12
High Energy Physics	PHY454Y	2	1	-	12
Solid State Physics	PHY455Y	2	1	-	12
Modern Optics and Radiation	PHY456Y	2	1	-	12
Group Theory and its Physical Applications	PHY457Y	2	1	-	12

*This Technical Elective must be a course offered by a department of the Faculty of Applied Science and Engineering.

SECOND YEAR CHEMICAL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Physiccchemical Principles in Chemical Engineering I	CHE201F	2	-	-	7
Analytical Chemistry	CHE204F	2	10.5	-	19
Industrial Process Operations I	CHE205F	3	-	3	13
Inorganic Chemistry I	CHE217F	2	-	-	7
Calculus	MAT280F	3	-	2	13
Non-Technical Elective					12
Term 2S					
Physicochemical Principles in Chemical Engineering II	CHE202S	2	3	-	10
Industrial Prccess Operations II	CHE206S	3	6	1	18
Organic Chemistry I	CHE207S	3	6	-	17
Applied Mathematics in Chemical Eng. I	CHE210S	2	-	1	9
Inorganic Chemistry II	CHE218S	2	-	-	7
Econcmics for Engineers	ECO281S	3	-	1	12

All students must complete Practical Experience APS299Y during their undergraduate program. This is normally satisfied during the summer periods between the Second and Third, or Third and Fourth Years.

THIRD YEAR CHEMICAL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Thermodynamics and Kinetics I	CHE301F	3	6	1	17
Fluid Mechanics and Heat Transfer I	CHE305F	2	-	1	8
Applied Mathematics in Chemical Eng. II	CHE321F	2	-	1	9
Organic Chemistry II	CHE309F	3	6	-	17
Mass Transfer Operations I	CHE310F	2	-	2	10
Open Elective					12
Term 3S					
Thermodynamics and Kinetics II	CHE302S	3	6	2	20
Mass Transfer Operations II	CHE311S	2	4	2	17
Fluid Mechanics and Heat Transfer II	CHE314S	2	1.5	1	12
Chemical Engineering Topics I	CHE320S	3	-	-	10
Open Elective					12

All students must take a one-term science course in either the Third or Fourth Year. Normally this course is selected frcm courses offered by the Department of Chemistry, Physics, Biochemistry, Mathematics, Biology, Geology or Gecgraphy in the Faculty of Arts and Science; courses cffered in other departments may also be acceptable. In Third Year the science course can be selected as an Open Elective.

Students are reminded of the necessity to complete the Practical Experience, APS299Y.

FOURTH YEAR CHEMICAL ENGINEERING

Term 4F		Lect.	Lab.	Tut.	Wt.
Thesis	CHE499Y	-	6	2	12
Public Speaking	CHE498Y	-	-	2	5
Chemical Engineering Topics II	CHE401F	3	-	-	12
Free Elective					12
three of:*					
Chemical Engineering Thermodynamics	CHE402F	2	-	1	11
Energy, Environment and Resources	CHE454F	2	-	1	11
Pulp and Paper Chemistry, Technology and Engineering	CHE417F	2	-	1	11
Industrial Biological Processes	CHE448F	2	-	1	11
Economic Evaluation in the Process Industries	CHE456F	2	-	1	11
Electrochemistry and Corrosion	CHE453F	2	-	1	11
Chemical Plant Design	CHE405F	-	-	6	11
Strategy of Product and Process Development	CHE408F	2	3	-	11
Advanced Separation Processes	CHE410F	2	-	2	11
Atmospheric Dispersion	CHE446F	2	-	1	11
Pipeline Transportation	CHE412F	2	-	1	11
Introduction to Nuclear Engineering	CHE427F	2	1.5	1.5	11
Polymer Engineering	CHE415F	2	-	1	11
Ceramics	CHE420F	2	-	1	11
Catalysis	CHE447F	2	-	1	11
Hydrometallurgy	MMS413F	2	-	1	11
Other Technical Elective					11
Term 4S					
Thesis	CHE499Y	-	12	1	20
Public Speaking	CHE498Y	-	-	2	5
Free Elective					12
three of:*					
Chemical Reactors	CHE432S	2	-	1	11
Process Modelling and Simulation	CHE407S	2	-	3	11
Applied Nuclear Chemistry	CHE418S	2	-	1	11
Environmental Engineering	CHE423S	2	-	1	11
Instrumental Methods	CHE425S	2	-	1	11
Advanced Inorganic Chemistry	CHE426S	2	-	1	11
Optimal Control	CHE431S	2	-	1	11
Selected Topics in Organic Chemistry	CHE434S	2	-	1	11
Plastics Engineering	CHE444S	2	-	1	11
Petroleum Engineering	CHE445S	2	-	1	11
Composite Materials	CHE413S	2	-	1	11
Nuclear Chemical Engineering	CHE449S	2	-	1	11
Innovation and Entrepreneurship for Chemical Engineers	CHE457S	2	-	1	11
Chemical Engineering in Medicine	CHE458S	2	-	1	11
Physical Chemistry of Iron and Steelmaking	MMS421S	2	-	1	11
Other Technical Elective					11

Students are reminded that they must take a one-term basic science course before graduation. If this requirement has not been satisfied in the Third Year, then a science course may be selected as either a Technical Elective or a Free Elective in the Fourth Year. *Any elective for which too few students register may be withdrawn.

SECOND YEAR ELECTRICAL ENGINEERING

Term 2F		Lect.	Lab.	Tut.	Wt.
Differential Equations	MAT290F	3	-	2	12
Engineering Mathematics	ELE200F	3	-	2	12
Circuit Theory I	ELE210F	3	-	2	12
Measurements Laboratory I	ELE212F	1	1.5	-	6
Materials Science	MMS270F	3	1.5	-	12
Dynamics	MEC205F	2	-	1	8
Economics for Engineers	ECO281F	3	-	1	12
Term 2S					
Computing and Numerical Methods	ELE201S	3	-	3	15
Electric and Magnetic Fields	ELE221S	3	-	2	12
Circuit Theory II	ELE211S	3	-	2	12
Measurements Laboratory II	ELE213S	1	1.5	-	6
Electronic Circuits A	ELE231S	3	1.5	1	15
Non-Technical Elective					12

THIRD YEAR ELECTRICAL ENGINEERING

Term 3F		Lect.	Lab.	Tut.	Wt.
Electromechanical Systems I	ELE312F	3	1.5	1	14
System and Signal Analysis A	ELE310F	3	-	2	14
Physical Electronics A	ELE335F	2	.75	.75	9
Fields and Waves	ELE320F	3	1.5	1	14
Probability, Errors and Noise	ELE302F	2	-	2	10
Open Elective					12
Term 3S					
Digital Systems	ELE314S	3	1.5	-	12
Electromechanical Systems II	ELE313S	3	1.5	1	13
System and Signal Analysis B	ELE311S	3	1.5	1	13
Physical Electronics B	ELE336S	2	-	1.5	9
Electronic Circuits B	ELE331S	3	1.5	1	14
Open Elective					12

Term 4F		Lect.	Lab.	Tut.	Wt.
Free Elective					12
Select additional courses from the following to total 72 units[2] for the term including at least 48 units from Group A.*					
Group A					
Thesis[4]	ELE498F	-	-	-	12
Thesis[4]	ELE496F	-	-	-	24
Communication Systems A	ELE416F	2	3	-	12
Switching Theory	ELE405F	2	-	2	12
→Computer Software Engineering I	ELE440F	2	-	2	12
Control Systems I	ELE410F	2	1.5	1	12
→Applied Optics	ELE448F	2	1.5	1	12
→Power Semiconductor Circuits [5]	ELE433F	2	3	-	12
Electronic Circuits C	ELE430F	2	3	-	12
→Electromagnetics	ELE420F	2	1	1	12
→Power System Analysis[5]	ELE413F	2	1.5	1	12
→Semiconductor Electronics	ELE435F	2	1.5	1	12
→Network Theory	ELE412F	3	-	2	12
Group B					
→Engineering as a Profession[5]	ELE449F	2	-	-	12
Other Technical Elective[3]		-	-	-	12

[1] Courses joined by arrows cannot be taken together because of timetable conflicts.

[2] For students proceeding at a normal rate.

[3] Any Third or Fourth Year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrollments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

[4] A thesis is compulsory. The minimum weighting is 12 for the year. The maximum permitted is 24 for the year. Thus the selections allowed are any one of ELE496F, 496S, 498F or 499S; or both of ELE498F and ELE499S. The selection must be approved by the student's thesis supervisor.

[5] Limited enrollment.

*Departmental electives for which there is insufficient demand may be withdrawn.

Term 4S		Lect.	Lab.	Tut.	Wt.
Free Elective					12
Select additional courses from the following to total 72 units[2] including at least 48 units from Group A.*					
Group A					
Thesis[4]	ELE499S	-	-	-	12
Thesis[4]	ELE496S	-	-	-	24
→Radio Systems	ELE422S	2	-	1	12
↳Computer Organization	ELE441S	2	3	-	12
→Communication Systems II	ELE454S	2	3	-	12
↳Electromechanical Systems III	ELE419S	2	1.5	1	12
→Illumination[5]	ELE447S	3	1.5	-	12
↳Biomedical Engineering[5]	ELE445S	3	1.5	-	12
→Power System Control[5]	ELE414S	2	1.5	1	12
↳High Frequency Active Devices	ELE423S	2	1.5	1	12
Control Systems II	ELE411S	2	1.5	1	12
→Switching Circuits	ELE432S	2	3	-	12
→Integrated Circuits	ELE431S	2	3	-	12
→Computer Software Engineering II	ELE442S	3	1.5	-	12
↳Electrical and Electronic Instrumentation[5]	ELE436S	2	3	-	12
Group B					
→Nuclear Instrumentation	CHE429S	2	1.5	1	12
↳Acoustic Theory and Noise Control	AER414S	2	1.5	-	12
Organizational Behaviour	IND426S	2	1	-	12
Other Technical Elective[3]		-	-	-	12

[1] Courses joined by arrows cannot be taken together because of timetable conflicts.

[2] For students proceeding at a normal rate.

[3] Any Third or Fourth Year courses offered by departments of the Faculty of Applied Science and Engineering and listed in the programs of this calendar are acceptable. Where enrollments are limited (as noted in the calendar) the student is responsible for obtaining the necessary approval. Other technical or physical science courses require the approval of the teaching department offering the course and the Department of Electrical Engineering.

[4] A thesis is compulsory. The minimum weighting is 12 for the year. The maximum permitted is 24 for the year. Thus the selections allowed are any one of ELE496F, 496S, 498F or 499S; or both of ELE498F and ELE499S. The selection must be approved by the student's thesis supervisor.

[5] Limited enrollment.

*Departmental electives for which there is insufficient demand may be withdrawn.

SECOND YEAR METALLURGY AND MATERIALS SCIENCE

Term 2F		Lect.	Lab.	Tut.	Wt.
Calculus	MAT293F	2	-	2	12
Introduction to Modern Physics	PHY282F	3	-	-	12
Mechanics of Materials	CIV204F	3	1.5	-	12
Structure of Materials and Metallography	MMS201F	2	3	1	12
Metallurgical Thermodynamics I	MMS202F	2	-	3	12
Non-Technical Elective					12
Term 2S					
Calculus and Differential Equations	MAT294S	2	-	2	12
Probability and Statistics	STA282S	2	-	2	12
Metallurgical Thermodynamics II	MMS203S	2	-	3	12
Materials Chemistry	MMS204S	2	-	2	10
Metallurgical Analytical Chemistry Lab.	MMS228S	-	3	-	5
Materials Science	MMS205S	2	-	2	10
Economics for Engineers	ECO281S	3	-	1	12
Practical Experience	APS299Y	-	-	-	-

THIRD YEAR METALLURGY AND MATERIALS SCIENCE

Term 3F		Lect.	Lab.	Tut.	Wt.
Differential Equations	APM391F	2	-	2	12
Mineral Processing I	MMS301F	2	3	1	12
Electrochemical and Kinetic Processes	MMS302F	2	-	4	12
Physical Metallurgy I	MMS304F	3	3	-	12
Ceramic Materials	MMS308F	2	-	2	12
Open Elective					12
Term 3S					
Numerical Methods	CSC382S	2	-	1.5	12
Transport Phenomena	MEC349S	3	1.5	1.5	12
Physical Metallurgy II	MMS303S	3	3	-	12
Extractive Metallurgy I	MMS305S	3	3	1	14
Surface Properties of Materials	MMS311S	2	-	1	10
Open Elective					12

FOURTH YEAR METALLURGY AND MATERIALS SCIENCE

Term 4F		Lect.	Lab.	Tut.	Wt.
Electrical Systems	ELE470F	3	3	-	13
Extractive Metallurgy II	MMS401F	3	1.5	2	13
Materials Engineering I	MMS432F	3	1.5	1	12
Thesis	MMS499Y	-	6	-	9
Free Elective					12
and one of:(1)(2)					
Mineral Process Design	MMS414F	1	3	1	10
Solid State Science	MMS402F	3	1.5	1	12
Term 4S					
Advanced Chemical Metallurgy	MMS406S	2	-	1	10
Pilot Plant Operations	MMS405S	-	-	-	4
Materials Engineering II	MMS408S	3	-	-	12
Thesis	MMS499Y	-	12	-	18
Free Elective					12
one of: (2)					
Metallurgical Operations Analysis	MMS407S	2	-	2	10
Mineral Processing II	MMS412S	2	1.5	-	10
Advanced Iron and Steel Making	MMS420S	3	-	-	10
and one of: (2)					
Advanced Materials Science	MMS411S	3	1.5	-	10
Applied Physical Metallurgy	MMS417S	3	-	1	10
Composite Materials	CHE413S	2	-	1	11

[1] With the approval of the Chairman of the Department, any other suitable technical course may be substituted as an elective.

[2] The student must consult with his assigned staff tutor before choosing Technical Electives. Departmental electives for which there is insufficient demand may be withdrawn.

On the following pages are brief outlines of the courses prescribed for students in the Faculty of Applied Science and Engineering, listed in alphabetical order of the prefixes (AER, CIV, etc.) which identify the teaching department. The suffix following the course number indicates the term in which the course is given; the second line of the description shows the program+ and year in which the course is prescribed, and the number of hours of lectures, laboratory and tutorial work per week, and the weight units assigned to the course. For example:

CHE423S ENVIRONMENTAL ENGINEERING
IV-2B; IV-6,5c (elective) 2 - 1 11

indicates a spring-term course offered by the Department of Chemical Engineering. It is a compulsory course for students in Fourth Year Geological Engineering, Option B, and is an elective course for students in Fourth Year Chemical Engineering and Fourth Year Engineering Science, Option C. The course consists of 2 hours lectures, no laboratory, and 1 hours tutorial per week, and has a weight of eleven units.

Many course descriptions include a statement of exclusions, prerequisites and corequisites for the information of students, but the absence of such a statement does not imply that the course does not have such conditions. In these statements, the solidus symbol (/) means OR, and the comma (,) means AND.

The recommendations for textbooks should be considered as tentative only, and subject to change. Students should therefore not purchase textbooks until they have been in attendance in the course, unless informed otherwise by their department.

Interpretation of suffixes to course numbers:

F: A first-term (Fall) course.
S: A second-term (Spring) course.
F/S: Indicates that the course given in the first term is repeated in the second term; a student may take one or the other, but not both.
Y: A course which continues over both terms.
L: A course extending beyond the end of session(These are not normally open to Engineering Students)

In some courses offered by the Faculty of Arts and Science, suffixes A,B and H are also used to distinguish Fall Term, Spring Term and full year courses respectively.

+Program codes:

1. Civil Engineering
2. Geological Engineering
3. Mechanical Engineering
4. Industrial Engineering
5. Engineering Science
6. Chemical Engineering
7. Electrical Engineering
8. Metallurgy and Materials Science

AEROSPACE SCIENCE AND ENGINEERING

AER301F MECHANICS
III-5a,5p; III-5g (elective) 3 - 1.5 12
Reference frames in relative translation and rotation, vector and matrix formulations. Dynamics of a single particle and of systems of particles. Lagrange's equations. Rigid body kinematics and dynamics, Lagrangian approach to vibrations of complex systems. Special topics by request. Primary Reference: class notes. Reference Books: Greenwood, Principles of Dynamics; Page, Introduction to Theoretical Physics, Principles of Mechanics.

P.A. Sullivan

AER302S MECHANICS OF STRUCTURES
III-5a 3 - 1.5 12
Basic theorems and principles in the theory of structures (strain energy, virtual displacements, mimimum total potential energy). General theory of bending of beams (unsymmetrical bending, thin walled structures, shear flow in multiflanged beams, open and closed sections). General theory of torsion (thin walled structures, multicell structures, shear centre). Theory of elastic instability (buckling of slender elastic struts, flat and curved plates, shells). Plane stress problems (Airy and Prandtl stress functions). Application of theory to the design of aerospace structures is given in tutorials.

R.C. Tennyson

AER303F AEROSPACE LABORATORY I
III-5a - 3 - 12
Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definiton and description, feasiblity analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER304S AEROSPACE LABORATORY II
III-5a - 3 - 12
Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER305S FLUID MECHANICS

III-5a 3 - 1.5 12

The physical concepts of fluid flow are developed along with the mathematics and illustrated via examples. Major topics are: introductory concepts and idealizations of real fluids; conservation equations (mass, momentum) for inviscid fluids; Bernoulli's equation; coordinate systems; boundary conditions; vorticity. and vortex theorems; potential flow; 3D sources, sinks, doublets, modelling of flow about "half body" and sphere; complex potential and corresponding 2D flows; conformal transformations; mapping of circle into other shapes; viscous flow; Navier-Stokes equations; Couette and Poiseuille flows; introduction to boundary layer theory. Reference Books: Prandtl and Tietjens, Fundamentals of Hydro and Aeromechanics; Streeter, Fluid Dynamics (1948 ed. only!); Lamb, Hydrodynamics.

H.S. Ribner

AER306S AEROSPACE CONTROL SYSTEMS

III-5a 3 - 1.5 12

Mathematical representatation of linear dynamic systems. Response of linear dynamic systems. Stability. Introduction of feedback, and system response. Root locus concepts. Nyquist plot. Frequency response. Identification of system variables, feedback possibilities, and sensing elements for aerospace sytems. Control of aircraft. Control of launch vehicles. Spacecraft attitude control. References: Dynamics and Automatic Control (D. McRuer, I. Ashkenas, D. Graham; Princeton Univ. Press); Analysis and Design of Space Vehicle Flight Control Systems (A.L. Greensite: Spartan); Dynamics of Atmospheric Flight (B. Etkin; Wiley).

P.C. Hughes

AER401F AERODYNAMICS

IV-5a (elective) 3 - 1.5 12

Thin airfoil theory, vortex theory, finite wings, compressibility effects, supersonic and hypersonic wing theory. Propulsion: momentum theorem, propeller actuator disc analysis, blade element approach, axial compressors and turbines. Air cushion vehicles. Aircraft performance; drag, basic performance parameters, range, turning flight take-off. Illustrative design methodology. Basic concepts in static stability and control. Reference Books: Kuethe and Schetzer, Foundations of Aerodynamics; McCormick, Aerodynamics of V/STOL Flight.

L.D. Reid

AER403F ADVANCED MECHANICS OF STRUCTURES

IV-5a (elective) 2 - 1.5 12

Matrix analysis of redundant structures including the force and displacement methods. Flexibility and stiffness matrices for structural elements derived, effects of thermal strains and structural cutouts. Automated techniques for determining redundant members. The finite element approach, derived, and applied to plates and shells. The method of individual displacements, with solutions given for buckling loads, natural frequencies and stress distributions in structures. Application of analytical methods to the design of aerospace structures is given in tutorials. Reference Books: J.S. Przemienicki, Theory of Matrix Structural Analysis, McGraw-Hill, New York(1968); Zienkiewicz, O.C. and Cheung, Y.K., The Finite Element Method in Structural and Continuum Mechanics, McGraw-Hill, London (1967).

R.C. Tennyson, J.S. Hansen

AER406F ENGINEERING DESIGN I

IV-5a (elective) - 3 - 12

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Emphasis is placed on projects permitting students to independently carry out the preliminary and innovative stages of design. Recent design projects include spacecraft design, vehicle simulator design, and air cushion vehicle design. Drawings and reports are prepared as required.

G.W. Johnston

AER407S ENGINEERING DESIGN II

IV-5a (elective) - 3 - 12

A number of multidisciplinary engineering design projects are carried out by the student under the supervision of staff and of experienced design engineers from industry. Emphasis is placed on projects permitting students to independently carry out the preliminary and innovative stages of design. Recent design projects include spacecraft design, vehicle simulator design, and air cushion vehicle design. Drawings and reports are prepared as required.

J.B. French

AER408F AEROSPACE LABORATORY III

IV-5a (elective) - 6 - 12

Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasiblity analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER409S AEROSPACE LABORATORY IV

IV-5a (elective) - 6 - 12

Prepared experiments and/or laboratory projects are performed in subject areas associated with the Aerospace curriculum. The projects involve application of material in various courses to the solution of engineering problems. The projects are interdisciplinary in nature, thus the solutions require a synthesis of accumulated knowledge. Students work singly or in small groups. The projects include: project definition and description, feasibility analysis and design, construction and assembly of apparatus (or prototype), and experimentation (or testing prototype). The submission of a formal project report is required.

A.A. Haasz

AER410S GASDYNAMICS

IV-5a (elective) 3 - 1.5 12

Fundamental phenomena occurring in compressible flows are treated. Basic thermodynamics and the equations of inviscid and viscous compressible flows are reviewed. Compressible flows in nozzles, diffusers, and ducts with viscous and diabatic effects, and shock and expansion waves in both steady and nonstationary flows including high temperature effects that cause departures from the perfect gas law and equilibrium, are discussed. The lectures are illustrated by a set of synthesizing analytic and engineering problems in a tutorial laboratory. Reference Books: Liepmann and Roshko, Elements of Gasdynamics; Shapiro, Dynamics and Thermodynamics of Compressible Fluid Flow; Glass, Shock Waves and Man. (Prerequisite: AER 305F).

I.I. Glass

AER411S STABILITY AND CONTROL OF AIRCRAFT

IV-5a (elective) 3 - 1.5 12

Introduction to the dynamics of aircraft. Full equations of motion are derived, and then linearized by small-perturbation methods. Topics considered include longitudinal and lateral stability, response to control inputs, and flight in atmospheric turbulence. Also discussed are flight-path calculations and methods for stability-derivative estimation. Suggested Reference Books: Etkin, Dynamics of Atmospheric Flight; Ashley, Engineering Analysis of Flight Vehicles. (prerequisite: AER401F).

J.D. DeLaurier

AER412S AEROELASTICITY

IV-5a (elective) 2 - 1.5 12

Static aeroelastic phenomena are studied, including divergence of slender wings, the effect of low aspect ratio, sweep and wing-aileron interaction. Various methods of solution are considered such as closed form, matrix format iteration and the Rayleigh-Ritz approach. A study of vibration and flutter of wings and control surfaces is presented with particular emphasis on those parameters which affect flutter speed. Reference Books: Fung, Y.C., An Introduction to the Theory of Aeroelasticity, Dover Paperback Publications (1969).

J.D. DeLaurier

AER414S ACOUSTIC THEORY AND NOISE CONTROL

IV-5a, 7 (elective) 2 1.5 - 12

Basic acoustic theory including acoustic plane waves in infinite medium, real fluid effects, radiation of sound in three dimensions, sound propagation in ducts, and architectural acoustics. Noise control theory including transmission and radiation of sound by solid structures, mufflers, filters, resonators, enclosures and porous lining, sound propagation outdoors, subjective response to noise and industrial sources.

H.S. Ribner, G.W. Johnston

AER415F FUNDAMENTALS OF LASERS, PLASMAS AND ENERGY

IV-5a,5e (elective) 3 - 1.5 12

Energy and its interrelation with society, including forms of energy, sources of energy, energy and the environment. Introduction to a plasma, review of Maxwell's equations, motion of charged particles, magnetic confinement of a plasma, plasma equations, review of atomic physics and quantum concepts, radiation from plasmas, plasma spectroscopy, controlled thermonuclear fusion. Introduction to laser physics and review of laser properties. Application of lasers to controlled fusion, plasma diagnostics, and isotope separation.

R.M. Measures

APPLIED MATHEMATICS
(Department of Mathematics)

APM288F DIFFERENTIAL EQUATIONS I
II-5 3 - - 12
Ordinary differential equations. Existence and uniqueness theorems. General theory of linear homogeneous systems. Asymptotic behaviour and stability. Linear non-homogeneous systems. Series solution of linear equations. with analytic coefficients, Bessel and Legendre equations. Boundary value problems. Sturm-Liouville systems. Green's functions. Eigenvalue problems. Stability of non-linear plane autonomous systems.

APM388F DIFFERENTIAL EQUATIONS II
III-5 3 - - 12
Classification of linear partial differential equations of second order, hyperbolic, parabolic and elliptic equations, initial value problems, the method of characteristics, boundary value problems, separation of variables, eigenfunction expansions, Fourier transforms, Green's functions, cylindrical and spherical functions with applications.

APM391F DIFFERENTIAL EQUATIONS
III-8; III-4, IV-4 (elective) 2 - 2 12
First and second order ordinary differential equations, operational methods, variation of parameters, solution in series. Bessel and Legendre functions, the Laplace transform, selected boundary value problems. (Prerequisite: MAT294S)

APM436S FLUID MECHANICS
IV-5 (elective) 3 - - 12
A study of flows in a Newtonian fluid, Stokes flows, boundary layers, shock waves, singular perturbations. Co-or prerequisite: APM351Y or equivalent.

APM446F APPLIED FUNCTIONAL ANALYSIS
IV-5 (elective) 3 - - 12
Fredholm and Voltera integral equations, applications to boundary value problems and partial differential equations, variational methods, nonlinear integral equations.

APM456S OPTIMIZATION AND CONTROL THEORY
IV-5 (elective) 3 - - 12
Theory of extrema for constrained problems; topics in non-linear programming, the calculus of variations, optimal control theory and applications. (Prerequisite: APM251Y/346S/451F/MAT350Y, or equivalent.)

APPLIED SCIENCE AND ENGINEERING-INTERDEPARTMENTAL

APS100F/S COMPUTER PROGRAMMING
I-1,2,3,4,6,7,8 1 - 3 10
The digital computing system as a device for numeric and non numeric transformation of numbers and symbols. Constants, variables and arrays; arithmetic and logical expressions; functions. Algorithms, represented by flow chart and computer languages. Conditional branching and looping; iteration; sub-programs; input/output. All of the above will be illustrated and implemented using the FORTRAN IV language. Applications will include root finding, numerical integration, sorting, iterative design and graph plotting. No previous computer experience is presumed.

APS101F/S COMPUTER PROGRAMMING
I-1,2,3,4,6,7,8 1 - 3 10
A course similar to APS100F/S, with particular emphasis on program structure, verification and documentation. Some previous computer experience at an elementary level is presumed.

APS299Y PRACTICAL EXPERIENCE
- - - 0
Students in the programs listed below are required to have, before graduation, practical work of a nature acceptable to the department concerned. This may be obtained during the summer vacations but work done before entering the Faculty may also meet the requirements. Instructions will be issued by the departments concerning the type of work which is acceptable. Practical experience certificate forms may be obtained from the departments and should be returned there when completed.

Program 1	600 hours	Program 6	600 hours
Program 2	600 hours	Program 8	600 hours

APS401S SOCIAL IMPACT OF TECHNOLOGY
IV (elective) 1 - 4 12
An interdepartmental seminar guided by interpretive lectures and based on intensive study of a number of diverse cases illustrating the effects of engineering works on communities and society. Examples; STOL transportation; world-scale petrochemical plant in Sarnia; engineering design and occupational health; projected energy supply for Ontario to 2000 A.D.; engineering and genetics; services for northern communities. Enrollment limited.

APS402F ENGINEERING LAW
IV (elective) 2 - 1 12
Selected topics of law relevant to the practice of engineering: duties and liabilities of engineers; partnerships and corporations; contracts and agreements; municipal law; labour legislation; patents; taxation; environmental legislation. Enrollment limited.

COCKBURN CENTRE FOR ENGINEERING DESIGN

CED101S ENGINEERING DESIGN
I (elective) 2 1.5 1 12
Lectures will deal with the sequence of design steps by which engineers find acceptable solutions for technological needs. These include need definition, ideation, problem modelling, feasibility and economic analysis, the decision process, specification and presentation. A series of seminars will be used to study "case" problems and to consider such topics as the engineer's responsibility to society. Laboratory time will be devoted to small group design projects. Textbook: Vidosic, Elements of Design Engineering.

I.G. Currie

CED201S ENGINEERING DESIGN
II-5 - - 6 12
This course provides instruction and experience in the application of engineering design techniques that lead from a stated technological need to an acceptable solution. Students work in small groups on design projects and will have lecture/discussion sessions on problem identification, ideation, design criteria, feasibility analysis and decision making. Special topics related to the projects, such as materials, economics, reliability, etc., will be covered as required. The projects will be carried through to the drawing and specification stage and, if possible, a prototype constructed. The submission of a formal project report and an oral presentation are required.

A.A. Haasz

CED401Y PROJECT DESIGN
IV (elective) - 2 3 12, - 2 3 12
This elective provides an unusual opportunity for small interdisciplinary student design groups to look at problems of social or technical relevance, to seek viable solutions, and, after having a prototype constructed, to test the proposed solution. Emphasis is placed on management of the design project and on group effectiveness. Considerable freedom is given in selecting a problem and in structuring the group to suit the interests and expertise of those participating. Usually three or more groups, with from three to ten members representing the various disciplines, will each complete separate two-term projects. Oral presentations of the results are made to a student audience and a report of each project is published. This course may be used for all or partial thesis requirements by arrangement with the student's department. A list of projects completed by previous classes and examples of the reports may be obtained from I.W. Smith, Room 229, Mechanical Building.

I.W. Smith

DEPARTMENT OF CHEMICAL ENGINEERING AND APPLIED CHEMISTRY

CHE101S CHEMICAL ENGINEERING PROJECTS
I-1,2,3,4,5,6,7,8 (elective) - - - 12
A course concerning several topics of wide interest to engineers, in which each student may choose three Chemical Engineering Projects during the term. Each five week project is given by a specialist in his field of interest and includes laboratory sessions during which the student may design and execute a particular investigation related to the lecture course. Some of the projects include:

Separation Processes (MacElhinney)
Nuclear Kinetics (Hewitt)
Fiber Engineering (Rozeiu)
Combustion (Sandler)
Polymer Engineering (Williams)
Photochromic Tracers (Hummel)
Ceramic Engineering (Barham)
Photochemical Smog (Boocock)
Rheology (Chaffey)
Bioengineering (Wayman)
Mineral Engineering (C.R. Phillips, R.B. Thompson)
Plastics Engineering (Woodhams)
Chemical Co-ordination Complexes (Smith, Burgess)
Catalysis (Phillips, M.J.)
Biomedical Engineering (Wang)
Insulin (Bett)
Electrochemical Engineering (Foulkes)

A topic will be given in any year in which more than 20 students elect to take it.

D. Barham and Staff in Chemical Engineering

CHE111F CHEMISTRY
I-1,2,3,4,6,7,8 (elective) 3 3 1 18
A basic course in physical chemistry covering the topics listed under CHE 112F but intended for students with little previous exposure to chemistry or inadequate training in chemistry.

S. Sandler and Staff in Chemical Engineering

CHE112F CHEMISTRY
I-1,2,3,4,6,7,8 (elective) 3 3 1 18
A general course in physical chemistry involving problems dealing with industrial and engineering applications. Topics discussed are stoichiometry and the mole concept, ideal and real gas behaviour, phase equilibria and colligative properties of solutions, chemical and ionic equilibrium, electrochemistry, thermochemistry and chemical kinetics.

The lecture course is supplemented by a series of laboratory experiments illustrating the principles discussed. Experiments include a gas-chromatographic study of fuel combustion, a study of caustic-chlorine, sulphuric acid and formaldehyde pilot plants, freezing point depression, molecular weight determination and binary distillations, qualitative analysis, heat of neutralization, kinetics, corrosion, pH and electro-chemistry.

S. Sandler and Staff in Chemical Engineering

CHE113F CHEMISTRY
I-1,2,3,4,6,7,8 (elective) 3 3 1 18
An enriched course in physical chemistry covering the topics listed under CHE 112F but intended for students who desire to learn as much about the subject matter as possible. Students entering Chemical Engineering and having Grade 13 chemistry or its equivalent are advised to take this course.

S. Sandler and Staff in Chemical Engineering

CHE150F CHEMISTRY

I-5 3 3 1 15

An introduction to physical chemistry. The lectures include the following topics: ideal and real gas behavior, phase equilibria and the Clausius-Clapeyron equation, colligative properties of solutions, chemical equilibria and the Gibbs free energy, electrochemical cells and the Nernst equation, and thermochemistry. The laboratory provides experiments illustrating the principles discussed in the lectures.

W.H. Burgess and Staff in Chemical Engineering

CHE201F PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING I

II-6 2 - - 7

The following topics are discussed: PVT behaviour of fluids and fluid mixtures (equations of state, principle of corresponding states, compressibility factors, etc.), reaction stoichiometry, energy conversion and thermochemistry, phase equilibrium and phase diagrams.

R.W. Missen

CHE202S PHYSICOCHEMICAL PRINCIPLES IN CHEMICAL ENGINEERING II

II-6 2 3 - 10

This course provides an introduction to chemical thermodynamics and chemical kinetics. The second law of thermodynamics is discussed and applied to solutions, phase equilibrium, reaction equilibrium, including cell reactions and surfaces; in kinetics attention is focussed on ideal reactor models, rate laws, reaction mechanisms and catalysis. Laboratory work involves experiments for both CHE 201F and CHE 202S.

R.W. Missen

CHE204F ANALYTICAL CHEMISTRY

II-6 2 10.5 - 19

The course consists of experimental work and lectures on qualitative and quantitative chemical analysis, illustrating the principles of equilibrium and coordination chemistry and of important instrumental methods, in particular electroanalytical and opticometric methods. The growing role of analytical chemistry in environmental engineering and in the setting of environmental standards will be discussed by way of examples. Experimental work can include an independent project designed to advance the knowledge in a selected field. Textbook: D.A. Skoog and D.M. West, Fundamentals of Analytical Chemistry, 2nd ed.

J.W. Smith, C.R. Phillips

CHE205F INDUSTRIAL PROCESS OPERATIONS I

II-6 3 - 3 13

The theory of momentum and heat transfer and the fundamentals of momentum, heat and mass balances of chemical engineering practice are discussed. A tutorial problem class accompanies this course. Textbooks: McCabe & Smith "Unit Operations of Chemical Engineering" 3rd Ed; Himmelblau, Basic Principles and Calculations in Chemical Engineering.

W.G. MacElhinney, J.W. Smith, I.H. Spinner

CHE 206S INDUSTRIAL PROCESS OPERATIONS II

II-6 3 6 1 18

The fundamentals of transfer processes are discussed with particular reference to heat transfer operations in chemical engineering. A laboratory illustrating the principles and practice of transfer operations is also given. A tutorial problem class accompanies the lecture material. Textbook: McCabe & Smith, Unit Operations of Chemical Engineering, 3rd Ed.

W.G. MacElhinney, M.J. Phillips, J.W. Smith, I.H. Spinner

CHE207S ORGANIC CHEMISTRY I

II-6 3 6 - 17

An introductory lecture and laboratory course in organic chemistry, with emphasis on structure. Textbook: Griffin, Modern Organic Chemistry.

D.G.B. Boocock, W.H. Rapson

CHE209F CHEMICAL SYSTEMS

II-5 3 3 - 12

The themes discussed are conservation, equilibrium and rate of change in chemical systems. These are applied to topics in various engineering fields. Laboratory work illustrating the principles with emphasis on individual projects accompanies the lectures.

R. Luus

CHE210S APPLIED MATHEMATICS IN CHEMICAL ENGINEERING I

II-6 2 - 1 9

Applications of probability and statistics to chemical and chemical engineering problems. The course includes material on quality control, sampling inspection, tests of significance, confidence intervals and least squares.

I.H. Spinner, D.E. Cormack, R.F. Hunter

CHE217F INORGANIC CHEMISTRY I

II-6 2 - - 7

Periodicity in physical and chemical properties of the elements are studied in relation to atomic structure. Descriptive chemistry of representative and some transition elements are correlated with structure. Textbook: Cotton and Wilkinson, Textbook of Basic Inorganic Chemistry.

R.E. Jervis, D. Barham

CHE218S INORGANIC CHEMISTRY II

II-6 2 - - 7

Useful quantum models are developed for atoms and for atomic and molecular orbital bonding mechanisms. Concepts discussed include: electronegativity, Z-effective, ionic compounds, covalent bond lengths and energies, partial ionic character of bonds, coordination and complexation.

D.G.B. Boocock, R.I. Hummel

CHE301F THERMODYNAMICS AND KINETICS I

III-6 3 6 1 17

This is a course in the thermodynamics and kinetics of non-equilibrium systems. A knowledge of the classical thermodynamics of equilibrium states is essential. These limiting laws are applied to real system problems and the irreversibilities of such systems are discussed in detail. The process rate laws which describe systems far removed from equilibrium are developed and applied in selected practical cases.

W.F. Graydon, W.H. Burgess

CHE302S THERMODYNAMICS AND KINETICS II

III-6 3 6 2 20

A re-statement of the material described in course CHE 301F with additional quantitative applications taken from Chemical Engineering practice.

W.F. Graydon, W.H. Burgess

CHE303F THERMODYNAMICS AND KINETICS I

III-5c 2 3 1 15

Review of thermodynamic principles and their mathematical formulation, including the first and second laws. The pressure, volume and temperature properties of nonideal substances and mixtures as represented by equations of state, corresponding-states correlations and thermodynamic tables. Flow processes. Chemical thermodynamics, including vapor-liquid equilibria and phase diagrams, equilibria involving multiple chemical reactions, and electrochemistry. Textbook: M.M. Abbott and H.C. Van Ness, Schaum's Outline of Theory and Problems of Thermodynamics, 1972.

C.E. Chaffey

CHE304S THERMODYNAMICS AND KINETICS II

III-5c 2 3 - 14

This is a course in the thermodynamics and kinetics of non-equilibrium systems. A knowledge of the classical thermodynamics of equilibrium states is essential. These limiting laws are applied to real system problems and the irreversibilities of such systems are discussed in detail. The process rate laws which describe systems far removed from equilibrium are developed and applied in selected practical cases.

W.F. Graydon, W.H. Burgess

CHE305F FLUID MECHANICS AND HEAT TRANSFER I

III-2B,6 2 - 1 8

Laminar and turbulent flow of Newtonian and non-Newtonian fluids, analogies between momentum and heat transfer, conductive, convective and radiative heat transfer; applications of fluid mechanics, heat transfer and energy conservation in industry and the environment.

M.E. Charles, J.W. Smith

CHE309F ORGANIC CHEMISTRY II

III-6 3 6 - 17

A continuation of course CHE 207S. Textbook: Morrison & Boyd, Organic Chemistry.

D.G.B. Boocock, W.H. Rapson

CHE310F MASS TRANSFER OPERATIONS I

III-2B,6 2 - 2 10

The study of the fundamentals of mass transfer. Theory and practice of applications to gas-liquid mass transfer processes, including gas absorption, stripping, drying and humidification. Textbook: R.E. Treybal, Mass Transfer Operations, 2nd ed.

D. Mackay, O. Trass

CHE311S MASS TRANSFER OPERATIONS II

III-6 2 4 2 17

The study of distillation, including extractive and azeotropic distillation, solvent extraction, adsorption, membrane and other separation processes. Illustrative laboratory experiments. Textbook: R.E. Treybal, Mass Transfer Operations, 2nd ed.

D. Mackay, M.V. Sefton, F.R. Foulkes, D. Basmadjian

CHE312F MASS TRANSFER OPERATIONS I

III-5c 2 - 2 12

Fundamentals of mass transfer; molecular diffusion in solids and stagnant fluids, mass transfer in simple laminar flows, turbulent transport; interphase transfer with chemical reaction; mass, heat and momentum transfer analogies; combined heat and mass transfer; gas absorption and stripping.

D.E. Cormack

CHE313S MASS TRANSFER OPERATIONS II
III-5c 2 - 2 12
A fundamental study of chemical engineering unit operations; humidification, distillation, solvent extraction, absorption and ion exchange.

D.E. Cormack

CHE314S FLUID MECHANICS AND HEAT TRANSFER II
III-6 2 1.5 1 12
A continuation of CHE305F with increased emphasis on fluid particle systems, two-phase flow and on important applications of fluid mechanics and heat transfer in the process industries and the environment.

M.E. Charles, D.E. Cormack

CHE316S CHEMICAL ENGINEERING PROBLEMS AND LABORATORY
III-5c - 3 2 10
Laboratory experiments and problems illustrating selected topics discussed in subjects CHE303F and CHE317S.

W.H. Burgess, W.F.Graydon

CHE317S POLYMER CHEMISTRY
III-5c 3 - - 12
An introductory course in the chemical structures and syntheses of polymeric materials including resins, plastics, elastomers and fibers. Emphasis will be placed on the more important commercial polymeric materials and their chemical modification by cross-linking, grafting and vulcanization. Textbook: K.J. Saunders, Organic Polymer Chemistry, Chapman and Hall (Methuen) 1973.

R.T. Woodhams

CHE320S CHEMICAL ENGINEERING TOPICS I
III-6 3 - - 10
The following topics are covered:

Chemical Engineering Economics
A systems approach to planning chemical enterprises. The objectives, profitability and benefit-cost analyses are discussed, as are criteria for engineering decisionmaking and typical Canadian and overseas engineering projects. Textbooks: Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers; de Neufville and Stafford, Systems Analysis for Engineers and Managers.

M. Wayman

Nuclear Process Fundamentals
Nuclear topics basic to the nuclear engineering and radiochemistry electives in subsequent terms. Topics treated will include: nuclear composition and energetics, spontaneous and induced nuclear processes, radioactivation, nuclear fission, neutron production and radiation interactions, elements of nuclear measurement.

R.E. Jervis

Design and Analysis of Experiments
Analysis and solution of chemical engineering problems which require knowledge of the rational design of experiments, treatment of experimental data and tests of hypotheses. The application of probability to selected topics of chemical engineering interest.

I.H. Spinner

CHE321F APPLIED MATHEMATICS IN CHEMICAL ENGINEERING II

III-6 2 - 1 9

Application of differential equations to problems of chemical engineering interest, and modelling of simple systems. Emphasis is on the formation of the differential equations together with their solution by analytical and numerical methods.

D.E. Cormack

CHE322F INTRODUCTORY ORGANIC CHEMISTRY

III-5c 2 3 - 12

A condensed introductory organic chemistry course. Topics covered include: the bonding of carbon, nomenclature, the preparation, reaction, and identification of functional groups, industrial applications and simple electronic effects. The laboratory course will emphasize simple techniques and illustrate common organic chemical reactions. Textbook: Morrison and Boyd, Organic Chemistry.

D.G.B. Boocock

CHE342S NUCLEAR REACTOR FUNDAMENTALS

III-5nt,5p 3 1.5 - 12

This course, using appropriate mathematic tools, explains in terms of fundamental physical processes the design considerations and operational behaviour of existing, projected, and conceptual nuclear reactor systems for the generation of useful energy or radiation products. The physical processes of importance are nuclear fission, nuclear fusion, neutron diffusion, and the interaction of various types of radiation with matter. Topics include the conditions for criticality, the kinetic behaviour and the control of fission chain reactors, as well as the projected criteria whereby controlled fusion will become a reality. Environmental aspects and the international implications of nuclear energy will be discussed. The laboratory periods provide a first-hand opportunity to study the kinetic response of the SLOWPOKE critical reactor and to perform reactor physics measurements on the uranium heavy-water neutron multiplying assembly. The use of radiation sources and modern nuclear instruments in a variety of applications is investigated. Electrical analogs are used to supplement kinetic studies of reactor systems. (Prerequisite: PHY 335F or equivalent) Textbook: Lamarsh, Nuclear Reactor Theory.

J.S. Hewitt

CHE401F CHEMICAL ENGINEERING TOPICS II
IV-6 3 - - 12
The following topics are covered:

Chemical Reactor Design
The various types of chemical reactors used in industrial processes are discussed with emphasis on the factors involved in their selection and design. The factors include flow and contacting patterns, reaction kinetics, reactor configuration, product distribution, catalysis and temperature and pressure effects.

R.W. Missen

Introduction to Process Control
An introductory course outlining methods of measurement, signal transmission and controller action. Modelling and analysis of control systems.

I.H. Spinner

Material Properties
An introduction to plastics, ceramics and metals and their properties with particular emphasis on corrosion and materials selection procedures.

M.V. Sefton

CHE402F CHEMICAL ENGINEERING THERMODYNAMICS
IV-6,5c (elective) 2 - 1 11
Thermodynamic properties of real gases and of ideal and non-ideal liquid solutions. Chemical reaction equilibria. Selected problems.

W.H. Burgess

CHE405F CHEMICAL PLANT DESIGN
IV-6,5c (elective) - - 6 11
This is a course based on synthesis and creativity. Teams of about 6 students each design and cost a chemical plant. The plants are chosen based on current Canadian needs and interests.

M. Wayman

CHE407S PROCESS MODELLING AND SIMULATION
IV -6 (elective) 2 - 3 11
The course covers the formulation, analysis and solution, both by analytical and digital computer methods, of mathematical models describing unsteady and steady state chemical and physical processes. Simple models familiar from previous courses, such as "stirred tank" and column operations are used at the outset and are gradually combined into more complex systems representing actual plant operations. These models involve mainly algebraic and ordinary differential equations. and the application of chemical engineering fundamentals (heat, mass and momentum transfer, thermodynamics and kinetics). Numerous practical examples, drawn from the chemical, nuclear, metallurgical, environmental and biomedical fields are used both in the lectures and tutorials. References: D. Basmadjian: Process Modelling Manual. R.G. Franks: Modelling and simulation in Chemical Engineering.

D. Basmadjian

CHE408F STRATEGY OF PRODUCT AND PROCESS DEVELOPMENT
IV-6,5c (elective) 2 3 - 11
The strategical approaches needed for the solution of engineering problems involving the creation of novel unit operation equipment and novel processes, both for chemical and non-chemical products.

R.F. Hunter, I.H. Spinner

CHE410F ADVANCED SEPARATION PROCESSES

IV-6,5c (elective) 2 - 2 11

Theory and application of a number of separation processes, including multicomponent distillation (using computational techniques), azeotropic and extractive distillation, liquid extraction, transient behaviour and cyclic processes, and solid-liquid contacting operations. Illustrative design problems. Textbook: C.J. King, Separation Processes

M.V. Sefton

CHE412F PIPELINE TRANSPORTATION

IV-6 (elective) 2 - 1 11

A course based on the theory and practice of moving gases, liquids and solids by pipelines both within chemical plants and over long distances. Operating pipeline systems are used as examples, and the course includes a feasibility and design study.

M.E. Charles

CHE413S COMPOSITE MATERIALS

III-5m,IV-6,8 (elective) 2 - 1 11

A course on the fundamentals of composite material design, fabrication and evaluation. The reinforcement of plastics, metals and ceramics with fibres and flakes will be discussed, and examples will be drawn from aerospace, and other areas where recent improvements in materials design has had a significant impact. Emphasis will be given to understanding the basic processes which contribute to the excellent properties which composite materials can have. Textbook: N.J. Parratt, Fibre Reinforced Materials Technology.

M.R. Piggott

CHE415F POLYMER ENGINEERING

IV-5m,6 (elective) 2 - 1 11

The solid state properties of polymers are discussed, particularly amorphous state and crystallinity. The rheological and viscoelastic properties are then outlined and the effect on these of degradation and failure mechanisms included. A large segment of the course applies to fabrication techniques, their principles, and the products produced. The over-all emphasis is on the relationship of the properties to the structure, and how these affect the uses. Textbook: H. Leverne Williams, Polymer Engineering (1975).

H.L. Williams

CHE417F PULP AND PAPER CHEMISTRY, TECHNOLOGY AND ENGINEERING

IV-6(elective) 2 - 1 11

The chemistry of wood in relation to pulping, bleaching and papermaking processes, the equipment involved and the economics of converting wood into paper.

M. Wayman, W.H. Rapson

CHE418S APPLIED NUCLEAR CHEMISTRY

IV-6 (elective) 2 - 1 11

An introduction to the principles and methods of radioisotope chemistry. Applications of nuclear techniques and radioactive materials in chemical technology and in nuclear power generating systems. Topics to be covered include: radioisotope methods of studying chemical reaction mechanisms and kinetics, chemical process development and process control, nuclear reactions applied to chemical analysis (activation analysis), radiation chemical processing.

R.E. Jervis

CHE420F CERAMICS

IV-6 (elective) 2 - 1 11

An introduction to the field of ceramics, including a description of the available raw materials, the production of refractories and glasses, and high-temperature experimental techniques.

D. Barham

CHE423S ENVIRONMENTAL ENGINEERING

IV-6, 5c (elective) 2 - 1 11

Strategy (management, law, economics) and technology for environmental control of chemical processes. Dispersion and effects of effluents in the environment. Environmental impact studies. Specifically the following are discussed: environmental standards and their bases, measurement parameters and methods, sampling and monitoring, atmospheric reactions and behaviour of wastes in water bodies, meteorlogical principles and dispersion, water treatment principles (primary, biolcgical, physical and chemical) and air pcllutiocn control principles (particles and gases).

C.R. Phillips

CHE425S INSTRUMENTAL METHODS

IV-6 (elective) 2 - 1 11

The subject is designed to emphasize the science of chemical instrumentation. The principles, techniques, and applications of gas-chromatographic, opticcmetric, electrometric and mass-spectometric methods of analysis are studied.

S. Sandler

CHE426S ADVANCED INORGANIC CHEMISTRY

IV-6 (elective) 2 - 1 11

Periodicity and trends in physical and chemical properties of the compounds of the principal elements are discussed. These are correlated, predicted and classified both in terms of classical concepts and equations of quantum mechanics.

R.L. Hummel

CHE427F INTRODUCTION TO NUCLEAR ENGINEERING

IV-3,5m,6 (elective) 2 1.5 1.5 11

Nuclear engineering aspects of: nuclear constitution and properties including cross-sections, energetics, radioactivity; production and use of radioisotopes; neutrons, slowing-down, diffusion of thermal neutrons; fission, the fission reactor; heat transfer; radiation measurement and control; materials for reactor fuel, can, moderator and coolant and their behaviour in the nuclear environment. Textbook: J.R. Lamarsh, Introduction to Nuclear Engineering, or A.R. Foster and R.L. Wright Jr., Basic Nuclear Engineering, 2nd Edition.

D.G. Andrews

CHE429S NUCLEAR INSTRUMENTATION

IV-7,5e (elective) 2 1.5 1 12

This course begins with a review of the origin and nature of nuclear radiation, emphasizing its effects on the electrical properties of matter. The theories of operation of the various components in nuclear detection and spectrometer systems are studied, including different sensing devices, amplifiers, and data analysers. Examples are given of application of these systems in the nuclear power industry and in industrial process instrumentation. The laboratory periods include experiments on nuclear spectrcscopy, material analysis by nuclear techniques, and nuclear reactor mcnitoring.

J.S. Hewitt

CHE431S OPTIMAL CONTROL

IV-6 (elective) 2 - 1 11

Fundamentals of optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: Lapidus and Luus, Optimal Control of Engineering Processes.

R. Luus

CHE432S CHEMICAL REACTORS

IV-6, 5c (elective) 2 - 1 11

An introduction to the design and analysis of chemical reactors. Topics are: chemical kinetics and development of the rate law, including homogeneous and heterogeneous systems and catalysis; reactor models (batch, tubular, stirred-tank), including isothermal, non-isothermal and adiabatic operation. Reference Book: O.Levenspiel, Chemical Reaction Engineering.

W.F. Graydon

CHE434S SELECTED TOPICS IN ORGANIC CHEMISTRY

IV-6,5c (elective) 2 - 1 11

A course on the creative aspects of applied organic chemistry. The topics to be discussed are selected from the Nobel Lectures delivered annually since 1902, and from outstanding Canadian contributions to synthetic organic chemistry. Special attention will be given to the mechanisms and the influence of molecular structures on the course of reactions. Various experimental techniques and their operating principles used in applied organic chemistry will be explained. Methods for the sequential degradation and the reconstruction of complex organic molecules will be illustrated with particular references to carbohydrates, proteins, heterocyclic compounds, steroid hormones, and alkaloids.

P.Y. Wang

CHE435F RATE PROCESSES I

IV-5c 3 - - 14

Introduction to momentum, heat and mass transfer. Transport properties from kinetic theory of gases. Fluid flow concepts, integral mass, force and energy balances, Bernoulli's equation, friction. Equations of motion and boundary layer equations. Turbulent transport. Compressible flow.

O. Trass

CHE436S RATE PROCESSES II

IV-5c 3 - - 14

Total energy and thermal energy equations. Heat Transfer: Fourier's laws, heat transfer coefficients and equations. Component mass balances, mass transfer coefficients and Fick's laws. Momentum, heat and mass transfer analogies. Applications of the above fundamentals.

O. Trass

CHE440S MODELLING AND SIMULATION OF CHEMICAL SYSTEMS

IV-5c (elective) 3 - - 14

Applications of elements of chemical and physical rate processes to Chemical Engineering problems. Chemical reactor stability, complex chemical system dynamics and process control. Application of analog, digital simulation, and hybrid computers to the solutions of problems in the above topics.

I.H. Spinner

CHE443Y ORGANIC CHEMISTRY
(elective) 2 3 - 12, 2 3 - 12
A comprehensive, elementary, organic chemistry course available to students in any year other than those enrolled in Program 6, intending to qualify for entrance into the Faculty of Medicine. Lectures and laboratories are scheduled at times convenient to those registered. The lectures cover the simple hydrocarbons, their halogen and oxygenated derivatives, amino derivatives, and other derivatives of importance to biological systems, all with emphasis on structure and functionality. The major part of the course is spent on amino acids, sugars, and fatty esters with emphasis on natural and synthetic polymers of biological interest or use. The concurrent laboratory emphasizes typical laboratory reactions of these classes of materials.

H.L. Williams

CHE444S PLASTICS ENGINEERING
IV 5c,5m,6 (elective) 2 - 1 11
An intensive study of the chemical and physical properties of plastics materials and their use in product design. The principles of reinforcement with respect to fillers, fibers, flakes and microballoons will be presented including the practical aspects of materials selection, processing, fabrication and evaluation. The tutorial periods will be devoted to actual case histories involving recent developments. Reference Book: The Modern Plastics Encyclopedia. Textbook: G. Lubin (ed.), Handbook of Fiberglass and Advanced Plastics Composites.

R.T. Woodhams

CHE445S PETROLEUM ENGINEERING
IV-6 (elective) 2 - 1 11
A course utilizing the principles of Chemical Engineering and presenting the fundamentals of engineering design and processing as they apply to refinery operations that produce petroleum products and important chemicals from petroleum.

W.G. MacElhinney

CHE446F ATMOSPHERIC DISPERSION
IV-6 (elective) 2 - 1 11
Problems of assessing the dispersive role of the atmosphere are considered, as well as related topics such as source sampling and effects of air quality on the feasibility of industrial plants and residential areas. Small groups will undertake a design project or impact assessment. Textbook: Seinfield, "Air Pollution - Physical and Chemical Fundamentals".

J.W. Smith

CHE447F CATALYSIS
IV-6 (elective) 2 - 1 11
An introduction to heterogeneous and homogeneous catalysis including adsorption, kinetics of catalytic reactions, the nature of the catalyst surface and a consideration of some specific catalytic reactions.

M.J. Phillips

CHE448F INDUSTRIAL BIOLOGICAL PROCESSES
IV-6 (elective) 2 - 1 11
Principles involved in the industrial handling of biological materials. Engineering operations in the manufacture of biologically active substances. There will be a short discussion of protein chemistry with emphasis on enzymes and protein hormones. One or more visits will be arranged to a plant operating in the biological field. (NOT OFFERED 1977-78)

H.D. Bett

CHE449S NUCLEAR CHEMICAL ENGINEERING

IV-6 (elective) 2 - 1 11

Nuclear reactor fuel cycles; large-scale production of transuranium elements; growth and decay of fission product nuclides; chemical processing of irradiated fuels - extraction, absorption, complexing, chemical separation; transport and storage of radioactive wastes; environmental problems; isotope separation by physical means - diffusion, centrifuges, cascades.

D.G. Andrews

CHE452F NUCLEAR SYSTEMS ANALYSIS

IV-5nt 2 1.5 1 12

This course is a continuation of material started in CHE342S. Multi-group, neutron diffusion theory is applied to reflected and heterogeneous thermal reactors. Time and temperature effects are considered for reactivity changes, including those due to fission products, fuel depletion, control rods, etc. In-core nuclear heat transfer topics are treated. Interactive systems analysis approach is used to investigate nuclear electric generating station design parameters. Laboratory and tutorial topics accompany course material.

J.A. Sovka and J¬S¬ Hewitt

CHE453F ELECTROCHEMISTRY AND CORROSION

IV-6,5c (elective) 2 - 1 11

This is an introductory course in electrochemistry and corrosion which has been designed to provide the student with a working knowledge of the subject areas. The topics covered include the physical chemisty of electrolytes, Faraday's laws, conductivity and ion transport in solution, electrodes, electrode kinetics, industrial applications (the electrolytic process industries, fuel cells; batteries, electrodialysis), and corrosion and corrosion control.

F.R. Foulkes

CHE454F ENERGY, ENVIRONMENT, AND RESOURCES

IV-6 (elective) 2 - 1 11

Society is moving steadily towards decreased dependence on non-renewable energy and material resources while seeking to ensure maintenance of a satisfactory environment. The role of applied chemical science in these changes is described with emphasis on Canadian conditions . Topics discussed in detail include: current and future energy sources, conversion usage and conservation; process effluent treatment and elimination; resource recycling; environmental impact assessment and ecosystem analysis; resources depletion; policies to ensure beneficial technical change; Canadian Arctic development. The course will consist of lectures and individual student projects and presentations on relevant topics.

D. Mackay

CHE456F ECONOMIC EVALUATION IN THE PROCESS INDUSTRIES

IV-6,5c (elective) 2 - 1 11

The course presents a clear conception of how to prepare and evaluate investment proposals. Practical applications will be discussed in addition to techniques and theories of investment evaluation. Emphasis will be placed on such topics as the reading and interpretation of financial statements; a firm's cost of capital; the economics and relative feasibility of new projects, plant modernization and expansion, "make or buy", "buy or lease", "replace or repair", "abandonment", and uncertainty and inflation in economic evaluations.

A.J. Szonyi

CHE457S INNOVATION AND ENTREPRENEURSHIP FOR CHEMICAL ENGINEERS
IV-6 (elective) 2 - 1 11
The course is intended to give the students an understanding of small chemically-oriented business enterprises to introduce skills needed to run a small business. The mechanics of launching a new small enterprise and its technical, economical, legal and financial aspects will be discussed. Case histories in the chemical and process industries will be presented. Enrolment limited.

A.J. Szonyi

CHE458S CHEMICAL ENGINEERING IN MEDICINE
IV-6 (elective) 2 - 1 11
Seminars on the application of chemical engineering principles to the understanding of biological phenomena, in particular human physiology, and to the solution of medical problems. Selected topics of broad current interest, such as membrane transport and artificial organ technology.

M.V. Sefton

CHE498Y PUBLIC SPEAKING
IV-6 - - 2 5, - - 2 5
Students make oral presentations before small groups involving some aspects of their thesis project and other technical subjects. Constructive criticism is provided by students and members of the senior staff. Corequisite; CHE499Y.

CHE499Y THESIS
IV-6 - 6 2 12, - 12 1 20
Normally an experimental research project conducted under the supervision of a senior staff member. The project may, however, have a theoretical or design emphasis. A progress report on the work completed in the Fall Term is required at the beginning of the Spring Term and will be weighted 20% in calculating the final grade for the course. The thesis must be submitted before the last day of lectures in the Spring Term. A significant part of the course is instruction in the Fall Term in workshop practice and public speaking.

Senior Staff in Chemical Engineering

CHE537F OPTIMAL CONTROL OF CHEMICAL SYSTEMS
IV-5c (elective) 3 - 1.5 14
Fundamentals to optimal control of engineering systems are developed from the state-space viewpoint. The use of dynamic programming, maximum principle, and other optimization procedures is established and illustrated for both the continuous and discrete time systems. Non-linear analysis is introduced by approximate analytic methods, phase-space representation and the application of some elementary principles of asymptotology. Textbook: Lapidus and Luus, Optimal Control of Engineering Processes.

R. Luus

CHE1107F APPLIED MATHEMATICS FOR CHEMICAL ENGINEERS
IV-5c (elective) 2 - 1 15
Review of basic modelling leading to algebraic and ordinary differential equations. Models leading to partial differential equations. Vector analysis. Transport equations. Solution of equations by: Separation of variables, Laplace Transformation, Green's Functions, Method of Characteristics, Similarity Transformation, others time permitting. Practical illustrations and exercises applied to fluid mechanics, heat and mass transfer, reactor engineering, environmental problems and biomedical systems. Lecture notes provided.

DEPARTMENT OF CIVIL ENGINEERING

CIV100F APPLIED MECHANICS
I-1,2,3,4,6,7,8 3 - 2 15
Statics: The principles of statics are applied to the composition and resolution of forces, moments and couples. The equilibrium states of frames are examined. Dynamics: Applications of the principles of dynamics are discussed for motion on straight and curved paths. Work, energy and momentum concepts are applied to particles, systems of particles and rigid bodies. Throughout statics and dynamics the free body concept is emphasized and vector algebra is used where it is most useful.
R.H. Mills and Staff in Civil & Mechanical Engineering

CIV101F MECHANICS (STATICS)
I-5 2 - 1 9
Translational and rotational resultants and equilibrants are discussed together with equivalent force systems in two- and three-dimensional space. Emphasis is placed on systems in equilibrium. Distributed forces, applications to structures, friction, method of virtual work, potential energy and stability of equilibrium are considered.
S.M. Uzumeri, B. Etkin

CIV135F/S ENGINEERING GRAPHICS
I-1,2,3,4,6,7,8 2 5 - 12
A course to provide an introduction to graphical communication in contemporary engineering practice. Topics in descriptive geometry and engineering drawing include orthographic projection, single view drawings, spatial analysis, developments and intersections, sketching, preparation of graphs and nomographs and the reproduction of drawings.
E. Kuhn and Staff in Civil Engineering

CIV136S ENGINEERING GRAPHICS
I-5 (elective) 2 - 2.5 12
A course on the use of graphical theories and methods as a means of visual communication in the development of engineering concepts. The lectures and laboratory problems deal with the ideas, problem refinement, solution analysis and solution implementation.
R.D. Foster

CIV203S MECHANICS OF MATERIALS
II-5 (elective) 2 - 3 12
Structural design philosophy and methods; structural properties of engineering materials: basic relationships between force and deformation of bars; behaviour of structural components subject to axial load, bending, shear, and torsion; stress and strain transformations; instability; design of simple structures.
K. Below

CIV204F MECHANICS OF MATERIALS
II-8 3 1.5 - 12
The fundamental relations among stress, strain and applied load are worked out for tension, compression, twisting and bending in the elastic and inelastic ranges, for various engineering materials. The buckling of struts and columns is examined. Laboratory: An experimental study of engineering materials and structural members under various loading conditions. (Prerequisite: CIV100F)
A.C. Davidson

CIV205S MECHANICS OF MATERIALS
II-4 (elective) 2 3 - 12
An introduction to the elastic behaviour of solids under various load conditions. The basic concepts of strength and stiffness are examined and their application to the design of elementary structural systems considered. Laboratory: An experimental study of engineering materials and structural members under load. (Prerequisite: CIV100F)
J.D. Barber

CIV209F ENGINEERING MATERIALS
II-1 4 2 1 14
Deals with the basic principles necessary for the undertaking and selection of materials used in Civil Engineering and points out the significance of these in practice. Fundamentals which provide a common basis for the properties of various materials are stressed. The laboratory time is devoted to demonstrations illustrating the fundamentals covered in the lectures. (Co-requisite: CIV210F)
J. Timusk, G.B. Craig

CIV210F STRENGTH OF MATERIALS
II-1,2 3 - 2 12
An introduction to the elastic and inelastic behaviour of solids under various load conditions . Stress, strain, and deformation relations are determined for members subjected to tension, compression, torsion and bending forces. (Prerequisite: CIV 100F)
V.R. Riley, P.M. Wright

CIV211S STRUCTURES I
II-1 4 - 2 15
As an introduction to structural engineering design, the topics include the study of loads, safety factors, structural members and systems. Continuing study of structural mechanics fundamentals covers virtual work, energy methods, stability, influence lines, and an introduction to vibration. (Prerequisite: CIV210F)
S. Otani, S.M. Uzumeri

CIV240S ENVIRONMENTAL SYSTEMS
II-1;IV-2C (elective) 2 1 - 9
An examination of the causes of environmental deterioration (through population growth, economic growth, urbanization and industrialization, resource exploitation and recreation) and their effects on natural and man-made systems. Technology of water, air, soil and noise pollution control. Examination of alternative strategies for environmental management.
G.W. Heinke

CIV255F SURVEYING
II-1 3 2 1 13
General principles and practice of surveying including: measurement of horizontal distances, horizontal angles, vertical distances. Survey calculations, sources of errors, corrections and adjustments. Route surveying, construction surveying and introduction to airphoto interpretation and photogrammetry.
B.J. Haynes, H.I. Macklin

CIV260F COMPUTER PROGRAMMING

II-1 2 - 2 11

This course continues the study of programming requirements and techniques introduced in course APS 100F/S; the full standard FORTRAN language is used; emphasis is placed on subprogram philosophy and organization, and on flow charts and program documentation. Engineering problem oriented languages such as ICES-COGO and ICES-STRUDL are introduced and used. Some experience is provided in the use of a time-shared interactive computing system and in computer graphics. (Prerequisite: APS100F/S)

R.A. Collins, P. Byer

CIV267S CIVIL ENGINEERING PROJECTS

II-1 2 2 2 12

An introduction to the role of the engineer in the solution of society's problems. Lectures, seminars and discussion periods by staff of all areas of Civil Engineering and guest speakers. Projects on qualitative solutions to engineering problems. Instruction and practice in presentation of technical data and reports.

Staff in Civil Engineering

CIV271S PROBABILITY AND STATISTICS

II-1 3 - 2 12

An introductory course which combines the theory of probability, including Binomial, Poisson, and normal distributions, frequency and sampling distributions, parameter estimation, hypothesis testing, experimental design and linear regression, with practical examples and exercises related to Civil Engineering.

G.N. Steuart

CIV312F STRUCTURES II

III-1 3 - 2 12

This course emphasizes the design of elastic determinate systems. Practical examples in designing and detailing of structures in steel and timber are studied. (Prerequisite: CIV211S)

M.P. Collins

CIV313S STRUCTURES III

III-1 3 - 2 12

This course deals with the analysis of indeterminate systems and introduces the design of reinforced concrete structures. Practical design of reinforced concrete members such as columns, beams, and one-way slabs are studied using the ultimate strength design method. (Prerequisite: CIV312F)

J. Schwaighofer

CIV314S STRUCTURAL DESIGN

III-2C 2 - 3 12

This course is an introduction to the design of steel, timber and reinforced concrete structures. Topics to be covered include types of loads, specifications, design of beams and columns, design of reinforced concrete slabs and an examination of the structural systems for light industrial buildings. (Prerequisite: CIV210F)

J.D. Barber

CIV321F SOIL MECHANICS
III-1,2C 3 1 - 11
Introductory course dealing with identification of soils for engineering purposes; permeability and seepage; in situ stresses, ground-water pressures, effective stresses; volume compressibility and time-rate of volume change; shear strength. Laboratory sessions include identification of soil samples and determination of mechanical properties of soil. (Prerequisite CIV210F).
T.C. Kenney, J.-C. Roegiers

CIV322S FOUNDATIONS
III-1,2C 2 - 2 10
Earth pressure, retaining walls, braced, strutted and tied-back excavations, bearing capacity, shallow foundations including spread footings, combined footings and rafts, deep foundations including piles and bored piers, settlement, slope stability. Tutorial sessions are devoted to design problems. (Prerequisites: CI210F, CIV321F)
F.A. De Lory, T.C. Kenney

CIV330F TRANSPORTATION SYSTEMS
III-1 3 - 2 12
A brief history of Canadian transportation development and a discussion of current policy, regulation and administration structure introduces a comparative study of transportation modes including their cost characteristics. The principles of location, flows on networks and the concepts of capacity and control are studied. The transportation planning process is introduced with emphasis on analytical techniques.
G.N. Steuart, R.M. Soberman

CIV338S URBAN AND REGIONAL PLANNING TECHNIQUES
III-1, IV-1 (elective) 3 - 2 12
This course provides an introduction to the basic techniques used by urban and regional planners in the planning process. Topic areas will include methods of analysis, forecasting, simulation techniques and the regulation of land use. Practical applications will be emphasized in a series of brief laboratory assignments.
R.W. McCabe

CIV340S MUNICIPAL AND HYDRAULIC ENGINEERING
III-1 3 1.5 2 15
Systems for the supply, distribution and storage of water and for the collection of wastewater and stormwater are studied in detail. Other municipal problems dealt with include; pumping stations, roads, land development, solid waste disposal and the financing and administration of public works. Individual and group design projects supplement the lectures. (Prerequisite: MEC 351F; Corequisite: CIV240S)
B.J. Adams, D.F. James

CIV358F SURVEY CAMP
III-1 - - - 12
At Survey Camp, students obtain further experience in the use of instruments and in the essentials of survey practice. Emphasis is placed on route surveys, higher order surveys, and topographic surveys. Students entering Third Year Civil Engineering will be required to take the Survey Camp from August 22 to September 6, 1977. The camp is held at Dorset and Gull Lake with students in attendance paying for the cost of their accommodation. Applications to defer attendance or for exemption from the camp must be made to the Secretary of the Faculty before July 15, 1977. (Prerequisite: CIV255F)
B.J. Haynes and Staff in Civil Engineering.

CIV370F ENGINEERING MATHEMATICS
III-1,2C 3 - 2 12
Numerical integration, solution of ordinary and simple partial differential equations by numerical procedures, solution of linear algebraic equations, mathematical programming. (Prerequisite: MAT280F)

G.T. Will, V.F. Hurdle

CIV375S ENGINEERING ECONOMICS AND DECISION MAKING
III-1, 2C 3 - 2 12
Design as selection between alternatives. Economic efficiency and other goals. The objective function and the use of optimization techniques. Time scale of consequences and its reduction. Interest rate and social rate of return. Market and non-market valuation. Economic life, replacement and salvage value. Treatment of risk and uncertainy. Public investment. Financing.

E. Hauer, P. Byer

CIV413S MODULAR CONSTRUCTION
III-1, IV-1 (elective) 3 - 2 12
Systems building approach, types of modular construction. Fundamentals of building science. Materials for modular construction analysis and design of various modular systems, including panelized construction, formless masonry construction, and prefabricated box units. Joining and erection techniques. Recent developments.

V.R. Riley

CIV414S ADVANCED ENGINEERING MATERIALS
III-1, IV-1 (elective) 3 - 2 12
A "state of the art" review of the properties of materials used in Civil Engineering construction with special reference to design considerations and criteria for selection and specification of materials. Related project work is intended to stimulate an innovative approach to the use of materials. A strong emphasis on concrete technology reflects the responsibility of the Engineer for the quality of concrete and its importance in Civil Engineering.

R.H. Mills

CIV416F REINFORCED CONCRETE I
IV-1 (elective) 3 - 2 12
This course covers the behaviour and ultimate strength of reinforced concrete structures. Members subjected to flexure, axial load, shear and torsion are treated. Detailing of reinforcement, the design of floor systems and the design of shear walls are covered. Emphasis is given to the relationship between recent research results and current building codes. (Prerequisite: CIV313S)

S.M. Uzumeri

CIV417S REINFORCED CONCRETE II
IV-1 (elective) 3 - 2 12
Prestressed Concrete - tension members, simple span and continuous span flexural members, columns and torsion resisting members. Slender reinforced columns. (Prerequisite: CIV416F)

M.W. Huggins

CIV419F INDETERMINATE STRUCTURES
IV-1 (elective) 3 - 2 12
Internal forces, support reactions, structural displacements and influence lines are computed for continuous beams, arches, closed rings, frames, trusses, Vierendeel trusses and grids. Slope-deflection, moment distribution, Kani, flexibility and stiffness methods, virtual work and Muller-Breslau principles, and Maxwell's law of reciprocal displacements are studied. An introduction to structural analysis by matrix organization is examined. (Prerequisite: CIV313S)

R.A. Collins

CIV420F CONSTRUCTION ENGINEERING
IV-1,2C (elective) 3 - 2 12
Consideration of the various aspects of engineered construction including selecting, planning, scheduling, estimating, bidding and controlling projects. With the aid of project slides, the methods and equipment used in the construction of power plants and dams, highways and bridges, tunnels, buildings, and marine facilities will be studied. Small groups using complete plans and specifications will solve a number of related assignments.

K.A. Selby

CIV421F FOUNDATIONS AND EARTHWORK
IV-1 (elective); IV-2C 3 - 2 12
Design and construction of: foundations for buildings, bridges and other structures including excavation, footings, piling, caissons; retaining walls, sheet pile bulkheads; fills, embankments, earth-fill and rock-fill dams including seepage, dewatering and grouting. The laboratory sessions include design problems and studies of case histories. (Prerequisite: CIV322S)

E.I. Robinsky

CIV422S ENGINEERING GEOLOGY
III-1,IV-1 (elective) 3 - 2 12
The study of engineering practice from a geological point of view. The behaviour of rocks and soils in building and engineering construction, foundations, tunnels, dams, and flood-control works with reference to the importance of the mineral composition of earth and rock materials, their geomorphic and geologic features and their stress history. Engineering case studies will include examination of groundwater, frost and landslide conditions, shoreline engineering, construction in permafrost, earthquake problems, and field investigations. (Prerequisite: GLG280S/GLG180S Exclusion: CIV423S)

E.I. Robinsky

CIV423S ENGINEERING GEOLOGY SEMINARS
IV-2C 3 - 2 12
Application of Engineering Geology to construction and natural problems, for example; foundation sites, dams, tunnels, landslides, coastal erosion, permafrost. The course will consist of lectures and seminars. Students will present orally the results of individual case histories or subject studies on selected topics. The instructional portion of CIV 474S, Public Speaking will be included in this course. (Prerequisites: CI421F, CIV424F, Exclusion: CIV422S)

T.C. Kenney and Staff in Civil Engineering

CIV428S DESIGN OF EARTH AND ROCK STRUCTURES

IV-2C 2 - 3 12

Design of: cuttings in soil and rock, embankments and dams of earth and rock fill and openings in earth and rock such as tunnels and cavities. Consideration will be given to: appreciation of site conditions, site selection, material selection and/or exploration, design and analysis, construction control, monitoring of performance, seepage control, remedial measures. Tutorial sessions will consist of design projects. (Prerequisites: CIV421F, CIV424F)

E.I. Robinsky, J.-C. Roegiers

CIV432S HIGHWAY ENGINEERING

IV-1 (elective) 3 - 2 12

A basic course in which the following topics are examined: highway systems and geometric design; highway materials and their behaviour; and, pavement systems. The laboratory part of the course is mainly devoted to a design project.

M.M. Davis

CIV456S ENGINEERING APPLICATIONS OF SURVEYING

III-1,IV-1 (elective) 3 - 2 12

Theory, methods and instrumentation of engineering surveys. Special applications in civil engineering structures such as: bridges, dams, tunnels, highways, airports, power lines, and pipelines. Introduction to hydrographic surveying. Engineering applications of and introduction to legal surveying as related to engineering projects. (Prerequisite: CIV 358F)

B.J. Haynes, H.I. Macklin

CIV468F CIVIL ENGINEERING SYSTEMS

IV-1 3 - 2 12

The analysis and design of comprehensive engineering systems by student groups, with examples from structural, geotechnical, transportation, and environmental engineering. Emphasis is placed on the evaluation of alternative technological designs and the integration of knowledge from many courses in the curriculum. Lectures and case studies are given on systems methodology, data analysis, sensitivity testing, and the incorporation of engineering, economic, and social considerations in design.

R.G. Rice, P. Byer

CIV474S PUBLIC SPEAKING

IV-1 - - 2 4

A subject emphasizing student participation and designed to develop facility in oral presentation before groups. Beginning with short talks, students move on to longer prepared talks on technical subjects. Experience and observation are also offered in the conduct of meetings.

H.L. Macklin & Staff in Civil Engineering.

CIV475S ADMINISTRATION AND MANAGEMENT

IV-1, 2C (elective) 3 - 2 12

An introduction to the various management functions involved in operating a business; including planning, organizing, staffing, directing, controlling and labour relations. Individual proprietorships, partnerships, and limited company operations are discussed. The practice of management in engineering environments will be studied with the aid of a number of cases.

K.A. Selby, H.I. Macklin

CIV479F/S SPECIAL STUDIES IN CIVIL ENGINEERING

IV-1 (elective) 3 - 2 12

Students having the Departmental Chairman's approval, may undertake special studies of advanced topics that are not normally part of the undergraduate program.

G.T. Will

CIV498F THESIS

IV-1 (elective) - 4 - 12

With the approval of the Departmental Chairman, a Fourth year student in Civil Engineering may undertake a 30-unit thesis instead of the usual 18-unit thesis (CIV499S). Normally such theses will be experimental in nature and the topic must be submitted prior to the commencement of the fall term.

P.M. Wright

CIV499F/S THESIS

IV-1 - 6 - 18

All students in the Fourth Year of the Civil Engineering program must prepare a thesis on an approved subject. Topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member. (Only those students who will complete the requirements for their degree in a fall term will be permitted to take CIV 499F.)

P.M. Wright

CIV505F ADVANCED STRENGTH OF MATERIALS

IV-1 (elective) 3 - 2 12

Selected topics from the following list are introduced or extended beyond their elementary treatment: elastic buckling of axially loaded bars; torsion of bars having non-circular cross sections; unsymmetrical bending of beams; beams on elastic foundations; curved beams; beam-columns; cables; rings; elementary theory of elasticity; elementary plate theory.

J. Schwaighofer

CIV518S BEHAVIOUR AND DESIGN OF STEEL STRUCTURES

IV-1 (elective) 3 - 2 12

The behaviour of structural elements and structures and their connection by welding and bolting are examined and related to design methods and criteria. Topics to be considered include repeated loading, brittle fracture, elastic-inelastic behaviour, buckling and ultimate capacity. (Prerequisite: CIV313S)

P.C. Birkemoe

CIV524F ROCK MECHANICS

IV-1 (elective); IV-2C 3 - 2 12

Physical properties of rock, fundamentals of rock behaviour, and theories of rock failure. Consideration of in situ stresses. Analysis of stress and strain. Elementary principles of design of open excavations and underground excavations. Consideration of testing, excavation support, and instrumentation.

J.-C. Roegiers

CIV525F SUBSURFACE EXPLORATION

IV-2C 3 - 2 12

Planning and executing subsurface explorations in soils and rock to obtain information for the design, construction control and operation of civil engineering and mining projects, and for carrying out remedial actions in the case of distressed structures or distressed areas. Indirect methods (mapping, shallow seismic, pumping, penetration), direct methods (boring, shafts, adits), in situ tests and field instrumentation will be considered. Case histories will be studied.

J. Morton

CIV529F AIR PHOTO INTERPRETATION

IV-1 (elective); IV-2C 3 2 - 12

Aerial photography; photo pattern elements in landform identification; identification of glacial, aeolian, alluvial, organic and major rock type landforms and discussion of associated engineering properties and problems; location of granular materials; soil drainage mapping; applications in highway location and site evaluation studies.

J. Vlcek

CIV530F TRAFFIC ENGINEERING

IV-1 (elective) 3 - 2 12

The course is an introduction to the principles and techniques of traffic engineering and public transport operations. The first part is devoted to the discussion of driver, vehicle, roadway and traffic stream characteristics and their implications for design and control operations. The second part of the course deals with: highway and intersection capacity, signal timing, area traffic control, bus route design and operation, and road safety management. (Prerequisite CIV330F).

E. Hauer, V.F. Hurdle

CIV531F TRANSPORTATION PLANNING

IV-1 (elective) 3 - 2 12

This course deals with the transportation planning process, with emphasis on urban and regional applications. Surveys and data collection, mathematical models and transportation demand analysis, transit and highway system alternatives, methods of project and systems evaluation.

R.G. Rice

CIV540F WATER AND POLLUTION CONTROL ENGINEERING

IV-1 (elective) 3 - 2 12

Environmental pollution, water and waste systems and the selection of pumps are reviewed briefly. Water quality, self purification of streams, soil pollution and the principles involved in the design and operation of water and wastewater treatment facilities are then studied in detail. Laboratory and field trips complement the lectures and class assignments.

J.G. Henry

CIV541S AIR POLLUTION CONTROL ENGINEERING

IV -1 (elective) 3 - 2 12

The pollutants: their sources, quantities and qualities, effects on humans, environment. Distribution and concentrations in city air under various atmospheric conditions, pollution indices. Control processes: change of fuel, dust control by cyclones and electrostatic precipitators; control of gases by adsorbers and scrubbers; exhaust controls for vehicles. Impacts on economy, planning, policy decisions.

E. Koczkur

CIV549S GROUNDWATER

IV-2C 3 - - 12

Ground water as an element of the hydrologic cycle; its relation to the geology of a basin and to water resources management. Mechanics of groundwater flow; methods of investigation, preservation and exploitation; groundwater pollution.

E.I. Robinsky, J.-C. Rogiers, B.J. Adams

CIV550F WATER RESOURCES AND HYDROLOGY

IV-1 (elective) 3 - 2 12

Management of water resources for optimal use. Systems approach and models for water resources studies. Rainfall, run-off and stream-flow analysis. Flood and water quality control by structural and non structural methods. Hydrologic effects of urbanization. New techniques for storm water management. Benefit cost analysis. Environmental, economic, sociological, legal and political factors affecting water management: examples related to the Great Lakes and to large power developments in Canada.

B.J. Adams

COMMERCE
(Department of Political Economy)

COM390F ACCOUNTING I
III-4 2 - - 12
Accounting methods and principles; build-up of financial statements. Enrollment limited.
M.S. Shapiro

COM391S ACCOUNTING II
III-4 (elective) 2 - - 12
Analysis and interpretation of financial statements; introduction to cost acccunting and managerial accounting. (Prerequisite: COM 390F)
M.S. Shapiro

DEPARTMENT OF COMPUTER SCIENCE

CSC180F INTRODUCTION TO COMPUTER PROGRAMMING
I-5 2 2 - 12
A practical introduction to structural programming using PL/1; numerical and non-numerical applications.
J.N.P. Hume, R.C. Holt

CSC280S COMPUTER LANGUAGES
II-5 (elective) 2 - 1 12
Definition of various programming languages including procedure oriented, list processing and simulation languages. Specification of syntax and semantics. Basic properties of programming languages. Introduction to formal languages and data structures. (Prerequisite: CSC180F)
J.J. Horning

CSC364S INTRODUCTION TO THE THEORY OF COMPUTATION
III-5cs 2 - 1 12
Introduction to formal logic - propositonal and predicate calculus. Primitive recursive functions, computable functions, recursive functions, recursive sets. Turing machines, unsolvable problems. Models, flowcharts, and program schemata; application to equivalence, termination, and correctness of programs. Text: Brainerd and Landweber, Theory of Computation.
C. Rackoff

CSC380S SYSTEM SOFTWARE I
III-5cs 2 6 - 15
An introduction to the facilities made available by modern hardware and operating systems. Data structures, including linear and linked lists, stacks, queues, trees. The principles of language processing. Formal grammars and parsing. (Prerequisites: CSC280S and ELE353F)
E. S. Lee

CSC381F NUMERICAL METHODS
III-4 2 - 2 12
Roots of equations, interpolation, approximation theory, quadrature, numerical solution of ordinary differential equations. (Prerequisites: IND202F, MAT293F, MAT294S. Exclusion: CSC382S, 383S)
A. Lehman

CSC382S NUMERICAL METHODS
III-2B,3,8 2 - 1.5 12
Linear systems of equations, interpolation and approximation, nonlinear equations, quadrature, ordinary differential equations. The emphasis will be on using numerical methods for the computer solution of such problems. Text: Conte and De Boor, Elementary Numerical Analysis, 2nd Edition. (Prerequisites: APS 100F/S, MAT 187S, MAT 189S. Exclusions: CSC381F, 383S)
R.I. Johnston

CSC383S NUMERICAL METHODS
III-5 2 - 1 12
The study of computational methods for solving problems in linear algebra, nonlinear equations, approximation, and ordinary differential equations. The aim is to teach the student the theory behind, and the intelligent use of mathematical subroutine packages currently available in computer libraries. Exclusions: CSC381F, 382S
J. Williams

CSC446S COMPUTATIONAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS
IV-5 (elective) 2 - 1 12
Initial value problems. Consistency, convergence, stability. Boundary value problems. Difference schemes, finite element methods. Mixed initial boundary value problems, nonlinear problems. (Prerequisite: CSC383S, Recommended: APM388F)

R.L. Johnston

CSC458S ARCHITECTURE OF DISTRIBUTED COMPUTER SYSTEMS
IV-5cs 2 - 1 12
Theoretical design and operational considerations of distributed computer networks. Data communication, system design and social implications of distributed systems. Discussion of existing systems. (Prerequisites: CSC380S, ELE353F)

C.C. Gotlieb

CSC468F OPERATING SYSTEMS
IV-5cs 2 - 1 12
Introduction to the design and implementation of multiprogramming operating systems Specific topics include concurrent processes, processor scheduling, memory management, file systems, protection and security, design and implementation methodology, and performance evaluation. (Prerequisite: CSC380S)

R.C. Holt

CSC478S APPLIED ALGEBRA
IV-5 (elective) 2 - 1 12
Algebraic theory which underlies symbolic and algebraic manipulation by computer; algebraic algorithms, Chinese remainder and interpolation theory; computation with integers, polynomial, and rational functions; symbolic matrix algorithms. The fast Fourier transform. Languages and systems for algebraic manipulation. Flowgraph theory with applications to graphs, automata, and Markov chains.

J.D. Lipson

CSC480S SYSTEM SOFTWARE II
IV-5cs 2 6 - 15
Continuation of topics in CSC 380S. Development of complete software systems. The organization of compilers, interpreters, assemblers, link editors, and loaders; tools which facilitate their construction. The laboratory associated with this course will include team projects producing pieces of system software. (Prerequisite: CSC380S)

R.C. Holt

DEPARTMENT OF POLITICAL ECONOMY

ECO281F/S ECONOMICS FOR ENGINEERS
II-1, 2, 3, 4, 5, 6, 7, 8 3 - 1 12
A survey course that includes opportunity costs, resource allocation, micro and macro economic theory and policy related issues. The micro-economic section deals with organization and structure of Canadian industry, public sector analysis, cost benefit analysis, project evaluation and general equilibrium. The macro-economic section deals with unemployment, inflation, international trade, economic growth and the policy issues related to these topics. This course has equivalent value to ECO100 as prerequisite for advanced courses in economics. It may not be combined with ECO100Y, 102Y or 103Y in any degree program.

ELE121S ELECTRICITY AND MAGNETISM
I-1,2,3,4,6,7,8 3 1 1 15
A basic course in electricity and magnetism including electric forces and fields, analysis of direct-current circuits, magnetic forces and fields, electromagnetic induction, and an introduction to the conductive, magnetic and dielectric properties of materials.

ELE150S ELECTRICITY AND MAGNETISM
I-5 3 - 1 12
An introduction to electricity and magnetism adapted to the needs of Program 5. Elements of vector calculus. Coulomb's Law. Gauss's Law. Electric field of discrete and continuous charge distributions. Potential functions. Gradient and divergence. Electrostatic forces and energy, capacitance. Forces on moving charges and conductors. Ampere's Law. Biot-Savart Law. Magnetic field of current rings and coils. Faraday's Law and Applications. Self and mutual inductance. Energy stored in a magnetic field. Circuit theory for transient and alternating currents. Electric and magnetic fields in matter. Textbook: Gartenhaus, Physics Basic Principles, vol.2

ELE200F ENGINEERING MATHEMATICS
II-7 3 - 2 12
Differential and integral calculus of functions of several variables with geometrical applications. Theory of Complex Variables, Cauchy-Riemann Equations. Complex integrals. Cauchy's integral theorem and formula. Taylor and Laurent series. Residues. Conformal Mapping and their applications to two-dimensional potential problems. Textbook: Kreyszig: Advanced Engineering Mathematics-Wiley (Prerequisites: MAT187S, MAT189S, Corequisite: MAT290F)

ELE201S COMPUTING AND NUMERICAL METHODS
II-7 3 - 3 15
The practical and efficient solution of electrical engineering problems with the aid of digital computers. Introduction to interactive computing with the APL language. Some algorithms for non-numerical applications such as sorting and network problems. An introduction to number systems and errors followed by a thorough study of certain algorithms for the solution of nonlinear equations(with particular attention paid to polynomial equations), the solution of systems of linear equations, eigenvalue problems, interpolation, approximation, numerical differentiation and integeration, and the numerical solution of differential equations. Some practical experience in all numerical algorithms will be included. Throughout the course stress will be placed on the "intelligent" use of package programs. (Prerequisite: MAT290F).

ELE210F CIRCUIT THEORY I
II-7 3 - 2 12
Circuits as models for physical devices; relationships between circuit and field concepts. Elementary network theorems and laws. Transient response of circuits. Topology and loop and nodal analysis. Response to complex frequency excitation. General solution of linear differential equations with constant coefficients. Steady-state response with direct and sinusoidal sources including analysis of polyphase circuits. (Prerequisite: ELE121S, Corequisite: MAT290F)

ELE211S CIRCUIT THEORY II

II-7 3 - 2 12

Complex frequency and network functions. Poles and zeros. Frequency response. The S plane. Resonance phenomena. Magnetically coupled circuits. Impedance transformations. Two-port networks. General network theorems. Transfer functions. Orthogonal functions and the Fourier series and transforms. Linear systems. (Prerequisites: ELE210F, ELE200F)

ELE212F MEASUREMENTS LABORATORY I

II-7 1 1.5 - 6

A laboratory course with explanatory lectures, dealing with basic electrical instrumentation, measurement techniques and appropriate methods for recording and reporting experimental results. See also ELE213S. Textbook: Wedlock and Roberge, Electrical Components and Measurements.

ELE213S MEASUREMENTS LABORATORY II

II-7 1 1.5 - 6

A laboratory course continuing the aims of ELE212F, dealing with measurement situations arising from the Circuit Theory Courses ELE210F, ELE211S.

ELE221S ELECTRIC AND MAGNETIC FIELDS

II-7 3 - 2 12

Introduction to vector calculus. Differentiation of vector functions. Gradient divergence and Gauss' Theorem. Curl of a vector field and Stokes' Theorem. The operator Del. The physics and geometry of electromagnetic forces and fields. Field analysis and computation. Macroscopic fields in material media. Dynamics of charge particles and current carrying conductions. Lumped and distributed descriptions of electromagnetic configurations (Prerequisites: ELE200F, ELE210F, MAT290F)

ELE231S ELECTRONIC CIRCUITS A

II-7 3 1.5 1 15

A communication system, an analog computer and digital computer, as examples of electronic systems. Identification of basic circuit functions. Passive RLC circuits as load and coupling circuits in both the time and the frequency domain. Ideal active elements: Amplifiers, operational amplifiers, controlled sources, logic elements and memory elements. Nonideal behaviour of amplifiers and their classification. Simple application of operational amplifiers. Qualitative description of pn junctions. Diodes and applications. Bipolar Junction Transistors: characteristics and models. Biasing of transistor circuits. Transistor amplifiers: AC coupled, DC coupled and differential. Field Effect Transistors. Transistor switching circuits. (Prerequisites: ELE210F, ELE212F, Corequisites: ELE211S, ELE213S)

ELE250F ELECTRIC CIRCUITS

II-5 3 1.5 1 12

Network elements and equations. Steady-state solutions, d.c. and a.c. Phasors and power. Transients: the time domain approach. Transients via Laplace transforms. Complex frequency; network theorems. Network functions, poles and zeros, frequency response plots. Fourier analysis. Textbook: M.E. Van Valkenburg, "Network Analysis", 3rd Edition. The laboratory will deal with the following topics:the cathode ray oscilloscope; impedance measurements; power measurements; frequency-domain measurements; measurements of transients. (Prerequisite: ELE150S, Corequisite: MAT295F)

ELE270F CIRCUIT THEORY AND MEASUREMENTS

II-3 3 1.5 1.5 12

Experimental laws. Techniques of circuit analysis. Duality. Source-free RL and RC circuits. The unit-step forcing function. The sinusoidal function. Phasors. The sinusoidal steady-state response. Average power and rms values. Polyphase circuits. Magnetically-coupled circuits. Electronic devices, introductory rectifier and logic circuits. Textbook: R.S. Smith, Circuits Devices and Systems, 3rd ed. - Wiley. (Prerequisite: ELE121S)

ELE271S ELECTRICAL ENGINEERING

II-4 (elective) 3 1.5 1 12

Analysis of single phase and three-phase circuits; transformers; physical foundation of electronic devices; electronic circuits; pulse and digital circuits; electromechanical energy conversion. Textbook: Fitzgerald, Higginbotham, Grabel, Basic Electrical Engineering (Prerequisite; ELE 121S or ELE 150S or equivalent)

ELE272S ELECTROMECHANICAL ENERGY CONVERSION

II-3 2 1.5 1.5 12

Ferromagnetism and magnetic circuits. The transformer. Principles of electromechanical energy conversion. Actuators. Steady-state operation of dc and ac machines. Introduction to systems control, analogue techniques, basic electrical instruments. Textbook: R.S. Smith, Circuits Devices and Systems, 3rd ed. (Prequisite: ELE270F)

ELE302F PROBABILITY, ERRORS AND NOISE

III-7 2 - 2 10

Basic principles. Probability, expectation, variance moments in discrete and continuous cases with emphasis on the former. Frequency distributions, density functions and characteristic functions. The Binomial, Poisson and Normal distributions. Random processes. Applications will be chosen from thermodynamics and statistical mechanics, scattering phenomena, radio noise etc. Sampling and statistical estimation theory, hypothesis testing. X^2 test. Least-squares fitting, correlation and regression. (Prerequisite: ELE211S)

ELE310F SYSTEM AND SIGNAL ANALYSIS A

III-7 3 - 2 14

System representation and analysis. Time domain analysis. Review of Fourier series and Fourier transform. Laplace transform. Study of the behaviour of continuous-time linear systems using transform methods. Transfer functions. Frequency response. Bode diagrams. Energy density spectrum, Stability, Routh-Hurwitz, Nyquist and root locus. Signal flow graphs. State variable formulation. (Prerequisite: ELE211S)

ELE 311S SYSTEM AND SIGNAL ANALYSIS B

III-7 3 1.5 1 13

Discrete time systems and the z-transform. Convolution integral and methods. Energy and power density spectra. Sampling theorem. Communication systems: time and frequency multiplexing; modulation and demodulation; AM, AM/SC, FM, PM, PAM, PWM, PPM. Characterization of random signals. Power density spectrum, Noise reduction. Spectral analysis. Textbook: Lathi, Communication Systems; Lathi, An introduction to Random Signals and Communication Theory. (Prerequisites: ELE213S, ELE310F, ELE302F)

ELE312F ELECTROMECHANICAL SYSTEMS I
III-7 3 1.5 1 14
Electromechanical energy conversion principles. Magnetic circuit analysis. Modelling of linear and non-linear magnetic systems, including permanent magnet systems. Single phase and polyphase transformers. Transformer design. Introduction to rotating machines. Textbook: Slemon, Magneto-Electric Devices; (Prerequisites: ELE211S, ELE213S, Corequisite: MEC205F)

ELE313S ELECTROMECHANICAL SYSTEMS II
III-7 3 1.5 1 13
Generalized approach to machines. Parameter evaluation. Steady-state and dynamic performance of DC, induction and synchronous machines. Introduction of multi-machine systems. Textbook: Slemon, Magneto-Electric Devices; (Prerequisite: ELE312F)

ELE314S DIGITAL SYSTEMS
III-7;III-5e(elective) 3 1.5 - 12
Introduction to basic logic operations, truth tables, algebraic manipulations, and combinational network design. Flip-flop storage elements, registers, and register transfer operations. Design and use of counters, encoders, decoders and multiplexers. Coding of information, 1's and 2's complement number representations, parity error checking. Designs for adders, multipliers, dividers. Magnetic core and integrated circuit memory systems. Design methods for control and data flow in digital systems. Basic design and operation of small digital computers, central processor structure, I/O methods, introduction to computer software at the assembly language level. Textbook: Peatman, The Design of Digital Systems. (Prerequisites: ELE201S, ELE231S or equivalent)

ELE320F FIELDS AND WAVES
III-7 3 1.5 1 14
Transmission line theory, Smith chart. One-dimensional elastic waves. Maxwell's equations. Propagation, reflection and refraction of plane waves. Theory of waveguides. Radiation from dipoles and antennas. Elementary theory of interference and diffraction. Textbook: Kraus, Carver, Electromagnetics. (Prerequisite: ELE221S)

ELE331S ELECTRONIC CIRCUITS B
III-7 3 1.5 1 14
Review of semiconductor device characteristics and applications; Multistage amplifiers, special configurations, frequency response, step response and square wave testing, system characteristics (electrical parameters); Logic circuits, basic logic elements, circuit analysis of standard logic families; Negative feedback, general concepts, analysis of transistor and op-amp feedback circuits, dominant pole compensation, oscillators. (Prerequisite: ELE231S, Corequisite: ELE336S)

ELE335F PHYSICAL ELECTRONICS A
III-7 2 .75 .75 9
Introductory quantum mechanics leading to the band theory of solids. Emission phenomena. Structure and basic properties of semiconductors. Hole and electron densities: impurities; generation and recombination processes. Carrier transport: the continuity equations. Semiconductor diodes: theoretical and practical aspects of pn junction, metal-semiconductor and other diode types. (Prerequisites: MMS270F, ELE231S).

ELE336S PHYSICAL ELECTRONICS B
III-7 2 - 1.5 9
Unipolar transistors; junction gate, M.I.S., and other surface devices: theory and circuit models. Bipolar transistors: fundamental theory, injection efficiency, base transport efficiency, small-signal low-frequency models. Charge storage models. High-frequency, small-signal analysis circuit models. PNPN devices. Fundamentals of integrated circuits: fabrication theory and technology: diffusion, epitaxy, oxide masking; capacitors, resistors, bipolar and unipolar transistor integration. Photoelectronics, solid-state optoelectronic phenomena: photoconductive and pn junction radiation detection. Image detection, storage and intensification. (Prerequisite: ELE335F)

ELE350F PHYSICAL ELECTRONICS I
III-5cs,5e;5p (elective) 2 .75 1 10
This course deals with the elementary theory underlying the technology and operation of semiconductor devices and the development of circuit models for these devices: Basic properties of semiconductors and carrier transport. Operation, theory and models of pn junction diodes, unipolar transistors (JFETs, MOSFETs) and bipolar transistors. Fundamentals of integrated circuit technology. (Prerequisite: PHY281S, exclusion: ELE335F)

ELE351F ELECTRONIC CIRCUITS I
III-5a,5cs,5e;III-5g,IV-5nt (elective) 2 1.5 1 12
Introduction to electronic systems. RLC circuit analysis: time and frequency domain, Bode plots, stability, linear wave shaping, nonlinear circuits, distortion, real life circuit components. Diode circuits: characteristics, models, clipping, clamping, gating, logic, power supplies. Field effect transistors - JFET and MOSFET: DC characteristics, biasing, AC model, design of simple amplifier circuits. Bipolar transistors: DC characteristics, biasing, AC models, design of simple amplifier circuits. Vacuum tube amplifier circuits. Introduction to computer aided design of electronic circuits. (Prerequisite: ELE250F, exclusion: ELE231S)

ELE352S PHYSICAL ELECTRONICS II
III-5e;5p(elective) 2 .75 1 10
Elements of band structure and electron dynamics. Energy distribution of electrons. Contact potentials. Electron emission. Application to: vacuum tubes, Schottky barrier diode, tunnel diode. Elements of transport theory. Application to: p-njunction, SCR, unijunction transistor, impatt diode, Gunn diode. Optoelectronics. Vacuum photo-electronic devices. Solid state photo-electronic devices. Liquid crystals. (Prerequisite: ELE350F, exclusion: ELE336S)

ELE353F COMPUTER ORGANIZATION
III-5cs;IV-5e(elective) 3 1.5 1 15
Digital system design principles. Registers and data flow. Computer structure, machine language instruction execution and sequencing, addressing techniques. Organization and design of central processing units. Microprogramming. Arithmetic operations. Memory hierarchy, direct and associative addressing. I/O techniques and channels. Some case studies of actual machines. Introduction to reliability. The laboratory will consist of experiments involving logic systems, and small computers, including microprocessors. (Exclusion: ELE441S)

ELE354S ELECTRONIC CIRCUITS II

III-5cs,5e;III-5g,IV-5a,5nt (elective) 3 3 - 14

Transistor amplifiers: high and low frequency response, step response, special connections (differential, Darlington, cascode, bootstrapping). Multistage amplifiers: bandwidth shrinkage, pole-zero location, step response, AC and DC coupling. Ideal active circuits: amplifier models, non-ideal behaviour, the operational amplifier and Op. Amp. circuits. Negative feedback: advantages, configurations, analysis and design of feedback amplifiers, stability, dominant pole compensation, oscillators. Transistor switching circuits: definitions and specifications, comparison of standard logic families, design of multivibrator circuits. Introduction to integrated circuits: technology constraints, design philosophy. Computer aided design of complex multi-transistor electronic circuits. (Prerequisite: ELE351F, exclusion: ELE331S)

ELE355F SYSTEM AND SIGNAL ANALYSIS I

III-5cs,5e 3 - 1 12

Signal representation by classical Fourier series and Fourier integral: orthogonality and completeness, pointwise and mean square convergence, inversion techniques, energy relations and time-bandwidth trade-off. Applications to circuits, sampling and modulation. Laplace transform: inversion techniques, application to transient analysis and frequency response of systems described by ordinary differential and differential-difference equations. Additional topics selected from: distributions, z-transform, discrete Fourier transform. (Prerequisites: ELE250F, MAT295F, MAT289S, or equivalent. Exclusion: ELE310S)

ELE356S SYSTEM AND SIGNAL ANALYSIS II

III-5e 3 1.5 - 12

Modelling of physical systems. State representation of dynamic systems as vector matrix differential and difference equations. Linearization. Controllability and observability. Steady-state performance and stability analysis for constant, linear systems employing Bode diagrams, root loci, Routh and Nyquist criteria. Synthesis of elementary feedback compensators. (Prerequisite: ELE 3355F, Exclusion: ELE311F).

ELE357F ELECTROMAGNETIC FIELDS

III-5e,5g,5p 3 1.5 1 14

Transmission lines. Smith chart. Maxwell's equations and constitutive relations. Plane waves in dielectric and conducting media. Wave polarization. Poynting vector. Waveguides. Retarded potentials. Radiation and antennas. (Prerequisites: ELE221S, or PHY280F; MAT289S)

ELE405F SWITCHING THEORY

IV-5cs,5e,7 (elective) 2 - 2 12

Boolean algebra, boolean functions. Design and minimization of combinational networks. Sequential machines, finite state models, synthesis, state assignment, state reduction. Synthesis and analysis of asynchronous sequential machines. Combinations of sequential machines. Identification. Textbook: Kohavi, Switching and Automata Theory. (Prerequisite: ELE 314S)

ELE410F CONTROL SYSTEMS I

IV-5e,7 (elective) 2 1.5 1 12

Review of steady-state and dynamic performance analysis, stability analysis and Bode diagrams. Linear compensation design. Process control design. Frequency and time domain analysis of nonlinear controllers; design of real control systems. (Prerequisite: ELE311S or 356S)

ELE411S CONTROL SYSTEMS II
IV-5e,7 (elective) 2 1.5 1 12
An introduction to the design of multivariable control systems using state-space methods. Vector-matrix differential equations as models for physical systems, and their solution by analytic and computational methods. Eigenvalues, eigenvectors, and modal analysis. Controllability; design of modal controllers. Observability; design of dynamic observers. Design of industrial regulators; integral feedback and feedforward control. Design using optimal control methods (Prerequisite: ELE410F or MEC357S or MEC455F)

ELE412F NETWORK THEORY
IV-5e,7(elective) 3 - 2 12
Network analysis and network functions. Properties and synthesis of LC and RC one-ports. Positive real functions, testing, realizations. Properties and synthesis of lossless singly-and doubly-terminated two-ports. Aprroximations to ideal filters. Introduction to active or digital filters as time permits. (Prerequisite: ELE311S, ELE201S)

ELE413F POWER SYSTEM ANALYSIS
IV-7 (elective) 2 1.5 1 12
Identification of the power system. Transmission lines, parameters and representation. Synchronous machines and other power system components. Behaviour of elementary power systems under fault conditions. Textbook: Stevenson, Elements of Power System Analysis (3rd Edition). (Prerequisite: ELE313S)

ELE414S POWER SYSTEM CONTROL
IV-7 (elective) 2 1.5 1 12
Control of power and frequency. Control of voltage and reactive power. Load flows. Stability limits. Underground transmission. Direct current transmission. Overvoltages and insulation requirements. Protection. Textbook: Weedy, Electric Power Systems, 2nd ed.(Prerequisite: ELE413F)

ELE416F COMMUNICATION SYSTEMS A
IV-7 (elective) 2 3 - 12
Spectral analysis, use of Fast Fourier transform, random signals and noise, analog and digital baseband communication, AM and FM systems, sampling and pulse transmission. The laboratory includes both computer problems and measurements on various modulation systems. Textbook: B. Carlson, Communication Systems, 2nd ed., McGraw-Hill. (Prerequisite: ELE311S)

ELE419S ELECTROMECHANICAL SYSTEMS III
IV-7 (elective) 2 1.5 1 12
Steady state and dynamic operation of both AC and DC industrial drive systems. Design of conventional and solid state control including position velocity and torque control applications. Introduction to elementary machine and machine system design. Elementary treatment of Linear Motors Systems for high speed transportation. (Prerequisite: ELE313S, Corequisite: EL410F)

ELE420F ELECTROMAGNETICS
IV-5e,7 (elective) 2 1 1 12
Basic considerations in solving field problems by such means as differential equations, graphical methods, and conformal transformations. Antenna system design. Wave propagation in anisotropic media. General analysis of guided waves. Textbook: Ramo, Whinnery and Van Duzer, Fields and Waves in Communication Electronics. (Prerequisite: ELE320F or ELE357F)

ELE422S RADIO SYSTEMS

IV-7 (elective) 2 - 1 12

An introduction to systems employing radio and light waves using selected examples from the fields of communications, remote sensing, navigation and traffic control. Emphasis will be on overall objectives, physical and economic constraints, means of implementation, basic system parameters and evaluation of performance. The impact of new technology on system design will be examined. (Prerequisite: ELE420F).

ELE423S HIGH-FREQUENCY ACTIVE DEVICES

IV-5e,7 (elective) 2 1.5 1 12

The purpose of the course is to introduce the theory, construction and applications of devices operating in the frequency range for which conventional electronic devices are not suitable The following types of devices will be discussed: Gunn, IMPATT and parametric amplifiers and oscillators in the microwave and millimeter frequency ranges, and laser type devices in the infrared and optical regions. The material will include the discussion of the required background physics and the limitations of the apparatus considered. (Prerequisites: ELE420F or ELE448F or ELE357F; exclusion: ELE414S).

ELE430F ELECTRONIC CIRCUITS C

IV-7 (elective) 2 3 - 12

A course on the analysis and design of analog circuits. Characteristics and applications of Operational Amplifiers: linear applications, instrumentation circuits, active filters, waveform generators, nonlinear applications. Circuit design techniques of IC op. amps. Frequency compensation techniques. Wideband amplifiers. Analog multipliers. Modulators and Demodulators. Phase-Lock Loops. (Prerequisites: ELE331S, ELE311S).

ELE431S INTEGRATED CIRCUITS

IV-7,5e (elective) 2 3 - 12

Design of integrated circuits with particular emphasis on the interaction between device and circuit design. Linear integrated circuit design techniques and limitations. Digital integrated circuits design evolution leading to large scale integration. (Prerequisite for IV-7: ELE 336S, ELE 331S; for IV-5e: ELE 352S, ELE 354S)

ELE432S SWITCHING CIRCUITS

IV-5cs;IV-5e,7 (elective) 2 3 - 12

A design course in electronic switching circuits. Static and dynamic characteristics of semiconductor devices as switching elements. Transistor multivibrators. Integrated circuit logic families. Linear and non-linear waveshaping techniques.Digital to analogue and analogue to digital conversion.Memory technology. (Prerequisites for IV-7: ELE314S, ELE331S; for IV-5: ELE354S, ELE314S or ELE353F)

ELE433F POWER SEMICONDUCTOR CIRCUITS

IV-7,5e (elective) 2 3 - 12

Diodes and power semiconductor switches. Specifications of thyristor or silicon controlled rectifier, AC voltage controllers, controlled rectifiers, DC to DC converters, inverters, applications to motor control. Textbook: Dewan and Straughen, Power Semiconductor Circuits.

ELE435F SEMICONDUCTOR ELECTRONICS
IV-7,5e (elective) 2 1.5 1 12
This course is concerned with certain theoretical and practical aspects of semiconductor devices. Electron dynamics in the crystal lattice distribution of carriers and properties of excess carriers will be discussed. P-n junctions, light emitting diodes, Gunn diodes, SCRs and other devices will be considered. (Prerequisite: ELE336S or ELE352S)

ELE436S ELECTRICAL AND ELECTRONIC INSTRUMENTATION
IV-7 2 3 - 12
This course is intended to provide the student with an understanding of both theoretical and practical instrumentation concepts. The course content will be both static to include a core of fundamental principles and dynamic to reflect topical measurement situations.

The initial portion of the course will concentrate on measurement concepts and the measurement of electrical quantities (e.g. voltage, current, power, static charge, e-m parameters). The next part will consider techniques for the measurement of components (e.g. diodes, transistors, power semiconductors, cables) and practical considerations of noise and its effect on electrical and electronic instrumentation. This will be followed by an examination of the possible measurement methodologies for the design of laboratory equipment in an attempt to illustrate why certain choices were made (commercially) and to emphasize the limitations of the apparatus. The final portion of the course will deal with the instrumentation necessary to measure and control an industrial process. The topic will be varied annually and will be approached from a cost-effective viewpoint in order to closely map the industrial environment and its consequent design constraints. (Prerequisites for IV-7: ELE314S, ELE430F; for IV-5e: ELE314S, ELE354S or ELE360S, Corequisite: ELE432S)

ELE440F COMPUTER SOFTWARE ENGINEERING I
IV-7,5e (elective) 2 - 2 12
This course is an introduction to computer system software engineering. Topics will include: Effective programming practice; Overview of machine structure and machine language; Data structures, including searching and sorting; High level language concepts, an introduction to formal grammars, and the design of language processors (Prerequisite: ELE314S or equivalent; exclusion: CSC380S)

ELE441S COMPUTER ORGANIZATION
IV-7,5e (elective) 2 3 - 12
The design of digital computers including the following topics: Control unit organization; series-parallel operation, control unit logic, microprogrammed control. Arithmetic units: addition, subtraction, multiplication, division, floating point arithmetic. Storage systems; core memory. I/O: I/O organization, interrupts. Microprocessors. (Prerequisite: ELE314S, exclusion: ELE353F)

ELE442S COMPUTER SOFTWARE ENGINEERING II
IV-7 (elective) 3 1.5 - 12
This course is a second-level treatment of some of the material introduced in ELE 440F Computer Software Engineering I. Topics will include the theory, detailed design, and implementation of language processors, including the effect of various language contructs and machine structures; and the principles and design of operating systems and data management systems. (Core-prerequisite: ELE440F; exclusion: CSC380S, CSC468F)

ELE445S BIOMEDICAL ENGINEERING
IV-7,5e (elective) 3 1.5 - 12
An introduction to some aspects of the interaction between engineering and medicine, given by the staff of the Institute of Bio-Medical Engineering:Basic physiology and anatomy, Biological communications processes, Nuclear medical engineering and radiation physics, Chemical aspects of Biomedical Engineering,Bicengineering in physiology. The laboratory gives the student the opportunity to measure physiological parameters and to use ultrasonic and nuclear devices. Opportunity will also be provided for the observation of surgical and other techniques. Textbook: Selkurt, Physiology; or McNaught, Callander, Illustrated Physiology. (Prerequisite: ELE331S and ELE310F or equivalent). Enrollment limited.

ELE447S ILLUMINATION
IV-7 (elective) 3 1.5 - 12
The course deals in general with the engineering problems which relate to the effective use of light (physical, physiological and psychological) in the everyday life of man. The topics covered include: the nature and characteristics of light; the production of light: incandescence and luminescence; the human eye, visual processes, and visual phenomena; radiometric and photometric units and laws; photometric measurements; calculation of photometric quantities; design of the visual environment: principles which relate to visual comfort and efficiency; colour and colorimetry; light sources - circuits and controls; visual problems at low light levels e.g. street lighting. Textbook: Stevens, Building Physics-Lighting.

ELE448F APPLIED OPTICS
IV-7 (elective) 2 1.5 1 12
Principles of ray optics and their applications to the design and analysis of optical systems including the theory of aberrations. Wave optics of isotropic and anisotropic media, interference phenomena and diffraction limits of optical systems. Textbook: Jenkins, White, Fundamentals of Optics. (Prerequisite: ELE 320F)

ELE449F ENGINEERING AS A PROFESSION
IV-7 (elective) 2 - - 12
The course will consist of a combination of lectures and seminars on the role of the Engineer in society. Topics to be discussed include: 1. Why does society not yet consider the engineer to be fully professional? 2. Does the engineer have a proper set of values? 3. Why does there not exist a philosophy of engineering? 4.Should the engineer bear the sole responsibility for the social consequences of his engineering projects? 5.What is the role of the engineer in such public issues as pollution, unemployment, urban development, etc. 6. The role of the engineer as an entrepreneur. Enrollment limited.

ELE452F ELECTRONIC CIRCUITS III
IV-5e (elective) 2 3 - 12
A design course in electronic circuits comprising: review of semiconductor devices, introduction to design philosophy, design of oscillators, power amplifier fundamentals, an introduction to modern switching regulators, operational amplifiers: circuits and compensation techniques, wide band amplifiers, narrow band amplifiers, active filters, multiplier circuits and applications, phase locked loops. (Prerequisite: ELE354S or 360S, exclusion: ELE430F)

ELE453F COMMUNICATION SYSTEMS I
IV-5cs,5e (elective) 2 3 - 12
Spectral analysis, use of the Fast Fourier Transform; AM and FM systems; pulse and pulse code modulation; random processes and noise in communication systems. The laboratory includes computer problems invclving the FFT and measurements cn varicus modulation systems. Text Book: B. Carlscn, Communication Systems. 2nd Ed. (Prerequisite ELE355F; exclusion ELE416F).

ELE454S COMMUNICATION SYSTEMS II
IV-5cs,5e,7 (elective) 2 3 - 12
Noise in communication systems. Noise figure and noise temperature. Performance of AM and FM systems. Digital data systems: modulation methods, probability of error, error contrcl coding. The laboratory includes both computer problems and measurements on various modulation systems. (Prerequisite: ELE416F or ELE453F)

ELE455S TECHNIQUES OF OPTIMIZATION
IV-5 (elective) 3 - 1 12
Calculus of variations. Maximum Principle. Linear and ncn-linear mathematical programming; dynamic programming; some problems in ccntrol theory; Applications will be drawn frcm engineering practice. (Prerequisite: APM 393F)

ELE470F ELECTRICAL SYSTEMS
IV-8; IV-2B (elective) 3 3 - 13
Electrical circuits, components, machines, sensors, transducers, instrumentation and ccntrols with emphasis cn practical applications, including heating and melting. Textbook: Lister, Electric Circuits and Machines(5th ed.).

ELE471F INSTRUMENTATION DESIGN
IV-3 (elective) 2 1.5 - 12
This course includes the theory, methods, and instrumentation required for the measurement of variables of interest to mechanical engineers;e.g., strain, liquid flow, air-flow, vibration, etc. Also included is a discussion of transducers required to convert these variables tc electrical signals, and the use of electronic modules in the design of equipment to process these signals. The interfacing of these modules with analcgue and digital recording and processing devices will also be covered.

ELE496F/S THESIS
IV-7 (elective) - - - 24
Each student in Electrical Engineering is required to write a thesis on an approved topic of his choice under the supervision of an academic staff member of the department. The thesis may involve experimental or other project-related activities. The weight to be attached to the thesis depends on the size of the thesis topic and must be approved by the student's thesis supervisor. The topic selected must be registered with the IV year thesis cccrdinator within two weeks of the beginning cf term. Further details are available from the Electrical Engineering Enquiry Office, G.146. (Prerequisite: completicn of all third year technical ccurses; exclusion: ELE498F, ELE499S)

ELE498F THESIS
IV-7 (elective) - - - 12
Same as ELE 496F, but of smaller weight. (Prerequisite: completion of all third year technical courses; exclusion; ELE496F/S)

ELE499S THESIS
IV-7 (elective) - - - 12
Same as ELE 498F but in spring term. (Prerequisite: completion of all third year technical courses; exclusion: ELE496F/S)

DEPARTMENT OF ENGLISH

Students' attention is also drawn to English offerings in the Faculty of Arts and Science. Full-year courses corresponding to the one-term courses listed below are: ENG108Y FORMS OF TWENTIETH-CENTURY LITERATURE; ENG152Y CANADIAN LITERATURE IN ENGLISH. See also: ENG112Y MAJOR BRITISH WRITERS; ENG140Y POETRY; ENG150Y AMERICAN LITERATURE; ENG165Y ENGLISH LITERATURE: FORMS AND APPROACHES. Students without the required pre- or co-requisite (one full-year course in English) may petition for admission to 200-series courses such as ENG220Y VARIETIES OF PROSE FICTION, ENG230Y VARIETIES OF DRAMA, and ENG270F/S SPECIAL STUDIES.

ENG281F/S EFFECTIVE WRITING

2 - - 12

This course is concerned with general problems of effective writing and with the proper use of language in prose composition. An "effective" writer knows how to express his ideas clearly and precisely, how to employ the laws of logic in ordering and supporting an argument, and how to use language persuasively. Classwork will involve discussion of the theory and method of various kinds of writing, supplemented by close consideration of examples of effective prose, but the main emphasis of the course is on frequent and varied practical exercises designed to develop writing technique. Enrolling students should have basic writing skills. Text: Strunk and White, Elements of Style.

ENG282F/S TWENTIETH-CENTURY LITERATURE I

2 - - 12

This course provides an introduction to prose fiction, drama, and poetry written in English during the twentieth century. Representative works of at least eight major authors will be studied, including: Conrad, Lord Jim; Lawrence, Sons and Lovers; Faulkner, As I lay Dying; O'Neill, Long Day's Journey into Night; Yeats, Selected Poems, ed. A. Norman Jeffares.

ENG283F/S CANADIAN LITERATURE I

2 - - 12

This course will deal with representative works of at least eight Canadian writers, and will consider some of the historical and cultural influences upon the development of Canadian writing. Texts studied will include: Laurence, The Stone Angel; Richler, The Apprenticeship of Duddy Kravitz; Davies, Fifth Business; Ryga, The Ecstasy of Rita Joe; Poetry of Mid-Century, 1940/1960, ed. Milton Wilson (NCL).

ENG284F/S VARIETIES OF FICTION I

2 - - 12

This course is designed to increase enjoyment and understanding of various forms of prose fiction through close consideration of at least eight representative works written in English, including: Bacon, New Atlantis, ed. Harold Osborn; Defoe, Moll Flanders; Dickens, Hard Times; Twain, Huckleberry Finn; Lawrence, The Rainbow.

ENG285F/S DRAMA AND THE MODERN THEATRE I

2 - - 12

This course is designed to increase understanding and enjoyment of drama through detailed study of at least <u>eight</u> major works and further study of at least <u>four</u> other works. The works for detailed study will include: a classical Greek play; a play by Shakespeare; a late seventeenth- or eighteenth-century play; a play by Ibsen; a play by Shaw or Brecht. The works for further study will be plays performed in Toronto during the term or other plays specially suited to discussion of theatrical production.

ENG286F/S LITERATURE AND SCIENCE I

2 - - 12

This course will explore some of the ways in which the methods and discoveries of science have made and are making an impact upon literature and will deal with at least eight significant works which were written in response to the scientific and technological ideas of their time. Works studied will include: Shakespeare, The Tempest; Swift, Gulliver's Travels; Mary Shelley, Frankenstein; Wells, The Time Machine; Huxley, Brave New World.

ENG292S TWENTIETH CENTURY LITERATURE II

2 - - 12

Continuation of ENG282F (Prerequisite ENG282F/S)

ENG293S CANADIAN LITERATURE II

2 - - 12

Continuation of ENG283S (Prerequisite ENG283F/S)

ENG294S VARIETIES OF FICTION II

2 - - 12

Continuation of ENG284F (Prerequisite ENG284F/S)

ENG295S DRAMA AND MODERN THEATRE II

2 - - 12

Continuation of ENG285F (Prerequisite ENG285F/S)

ENG296S LITERATURE AND SCIENCE II

2 - - 12

Continuation of ENG286F (Prerequisite ENG286F/S)

DIVISION OF ENGINEERING SCIENCE

ESC497Y,498F,498S,499Y THESIS
IV-5

Every student in Fourth Year Engineering Science is required to prepare a thesis on an approved subject. Instructions concerning the thesis requirements are issued during the Spring Term of Third Year, and copies may be obtained in the Division office. The weight allocated in each term of each option is shown in the Fourth Year curriculum. The full year theses will be graded after submission in the Spring term, and the grade included in the weighted average for that term only. The weight assigned will be the sum of the weights for both terms. A design project as described under CED 401Y may be undertaken in lieu of thesis.

GLE201F TOPICS IN GEOLOGICAL ENGINEERING

II-2 2 - 2 10

A survey course to acquaint students with engineering problems and their solution in areas of the three options in the program and to inform the student of the type of engineering in which they might be engaged in professional practice. About one half of the course will be on mineral engineering. The remainder will be divided equally between mineral exploration and geotechnical engineering.

Co-ordinator: F.A. De Lory

GLE301F PLANNING AND MANAGEMENT OF MINERAL EXPLORATION I

III-2A,2B;IV-5g(elective) 3 - 1 12

This course, in conjuction with GLE 302S is a basic course in the essentials of planning, management, and economics of mineral exploration, development and production. It is directed to those students who may decide on a career in the mineral industry. The course will include a historical review and role of exploration; organization, administration, management and supervision of mineral exploration; financing, budgeting and expenditures of mineral exploration; legal aspects of property acquisition; exploration philosophy, political, economics; metallogeny; selection of areas and methods; property evaluation; planning and logistics of exploration; selection of geological, geochemical, and geophysical methods. Case History studies. (Prerequisites; GLG141S/180S, GLG220Y.)

S.W. Holmes

GLE302S PLANNING AND MANAGEMENT OF MINERAL EXPLORATION II

III-2A,2B;IV-5g (elective) 3 - 1 12

This course is a continuation of GLE 301F and will include discussions of diamond drilling, contracting, methods, choice of equipment evaluation of data, decision making, feasibility studies, production decision, financing, development, choice of mining methods, mine management, ore reserves, sampling procedures, grade control, mining geology, and Case History studies. GLE 301F and GLE 302S will take the student through the programming and critical path of exploration projects from from prospecting to production decisions. The course will be supplemented by visits to various exploration departments of mining companies and will be augmented by speakers who are specialists in their particular disciplines. Much emphasis will be placed on Case History studies. (Prerequisite: GLE301F)

S.W. Holmes

GLE401F ECONOMICS OF MINERAL RESOURCES

IV-2A, 2B 3 - 1 12

The application of basic economics to mineral resources and the mineral industry including specific examples of supply and demand and consideration of mineral policy, mineral trading, taxation, government policy and environmental protection.

G. Anders

GLE492S,493Y,494S,495Y,496S THESIS
IV-2

Every student in fourth year Geological Engineering and Applied Earth Science is required to prepare a thesis on an approved subject. The Option A thesis (GLE 492S) is a Spring Term thesis and topics are normally submitted for approval in the fall term with the work being done in the spring term under the supervision of a faculty member. For Option B, the thesis (GLE493Y) will normally involve experimental as well as other project related activities and will be done throughout both Fall and Spring terms. For Option C the thesis is normally a Spring Term thesis (GLE 496S) with the topic submitted for approval in the fall term and the work done in the Spring Term under the supervision of a faculty member. With the permission of the Chairman of the Division a 24 unit thesis extending through both terms (GIE 495Y) may be taken.

DEPARTMENT OF GEOLOGY

GLG140F PRINCIPLES OF PHYSICAL GEOLOGY
III-5g;II-2 (elective) 2 2 1 12
Principles of physical geology and the evolution of the earth as a planet. Topics include the composition and form of minerals and rock bodies, the deposition of sediments by rivers and oceans, the origin of mountain systems and the development of global structures. Air photographs, geological maps and cross sections are used in studying the effects of geologic processes. A field trip is taken in October. .(Exclusions GLG110S,180S)

E.W. Nuffield

GLG141S PRINCIPLES OF HISTORICAL GEOLOGY
II-2,III-5g 2 2 1 12
A lecture-laboratory course that traces the history of the earth and its changing environment from the sequence of physical and biological events revealed in the rock record. Paleontology and concepts of geologic environments and time are emphasized in the laboratory and in the field. (Prerequisite: GLG 180S or 140F)

R. Ludvigsen

GLG180S APPLIED PHYSICAL GEOLOGY
I-1,2,3,4,5,6,7,8 (elective) 3 1.5 - 12
Fundamentals of physical geology as related to engineering problems and practice. Configuration of the planet and the effects of external and internal processes that act upon it; influence of earth processes as a factor in the design of engineering structures. Students will gain a knowledge of earth materials, their occurrence and uses. Textbook: Flint & Skinner, Physical Geology (Exclusion: GLG140F, 181F, 280S)

S.D. Scott, A.J. Naldrett

GLG220Y INTRODUCTORY MINERALOGY AND PETROLOGY
II-2;III 5g (elective) 2 3 - 12,2 3 - 12
First term: The principles of mineralogy, including crystallography, physical properties, chemical properties, origin and occurrence of minerals, descriptive mineralogy of approximately 80 common or useful minerals. Second term: The principles of optical mineralogy and identifiaction of principal rock-forming minerals in thin section by useof the polarizing microscope, introduction to petrography. (Prerequisite: GLG140F; Corequisite: GLG141S)

J.CD.H. Gorman, J.G. Gitting

GLG280S APPLIED PHYSICAL GEOLOGY
II-I (elective) 2 1.5 1 12
A course similar in content to GLG180S. Exclusion: GLG180S.

A.M. Goodwin

GLG320Y PETROLOGY
III-2A 2 3 - 12, 2 3 - 12
The principles of igneous, sedimentary and metamorphic petrology with major emphasis on examination of criteria used for the classification of the major rock types: The interpretation of rocks as indicators of crustal and mantle processes. Laboratory work covers the use of hand specimen and thin section techniques in the description and identification of rocks and the preparation of petrographic reports for problems in applied geology related to mineral exploration, mineral extraction, rock mechanics and geotechnical engineering. (Prerequisite: GLG 220Y)

J.J. Fawcett, J.E. Currie

GLG321F STRATIGRAPHY AND SEDIMENTATION

III-2A,2C 1 3 - 12

The properties and classification of sediments and strata. Sedimentary environments and tectono-environmental concepts in stratigraphy; the influence of global tectonics on local stratigraphy. Stratigraphy applied to mineral exploration. (Prerequisite: GLG 141S, 220Y)

F.W. Beales

GLG325F FIELD COURSE I

II-2 - - - 12

A field course in the Elliot Lake - Sudbury area emphasizing elementary mapping methods and basic field techniques applicable to structural - stratigraphic studies. A fee, recently $100., is charged to cover part of the cost of transportation and accommodation. The course is conducted immediately following the conclusion of the Spring examinations. (Prerequisite: GLG220Y)

Staff

GLG326F GLACIAL AND PERIGLACIAL GEOLOGY

III-2C 2 3 - 12

Elements of glaciology; character and origin of glacial deposits and landforms, geological process, sediments, landforms and frozen ground phenomena in the periglacial environment; glacio-isostatic crustal movements; eustatic changes in sea level; glacial history of North America with special emphasis on Ontario; local field trips. Laboratory exercises will focus on two major themes: (1) physical attributes of glacial and periglacial deposits as seen in the field and laboratory, and (2) terrain analysis using vertical air photographs, photo-mosaics and topographic, geologic and soils maps. (Prerequisite: GLG 141S)

W.M. Schwerdtner, J.A. Westgate

GLG327S PRINCIPLES OF PRECAMBRIAN GEOLOGY

III-2A 2 2 - 12

The stratigraphy, tectonic divisions and economic aspects of the Precambrian. Laboratory study of geological maps and reports; examination of typical rock suites in hand specimens and thin sections. (Prerequisite: GLG 321F)

A.M. Goodwin

GLG330F PHASE DIAGRAMS FOR GEOLOGISTS

III-2A 3 - - 12

Principles of phase equilibrium as applied to multicomponent silicate, sulphide and oxide systems over a wide range of temperatures and pressures of geological interest.

S.D. Scott

GLG331S INTRODUCTION TO GEOCHEMISTRY
III-2A 3 - - 12
Chemical aspects of geological processes, at and beneath the earth's surface. Textbook: Krauskopf.(Prerequisite: CHM 100F)

G.M. Anderson

GLG332F GEOMETRY AND KINEMATICS OF TECTONIC STRUCTURES
III-2A,2C 1 3 - 12
Geometry of major deformational structures in the earth's crust, notably of faults, joints, and folds. The course is built around the mechanical concepts of displacement and stress, and emphasizes general principles of structural geology. It is shown how the major deformational structures relate to modern tectonic hypotheses of mountain building and crustal evolution. (Prerequisite: GLG220Y)

W.M. Schwerdtner

GLG333S ANALYSIS OF TECTONIC STRUCTURES
III-2A,2C 1 3 - 12
Kinematic and dynamic analysis of existing structures, based on principles of rock mechanics. The course is built around the concepts of stress and finite strain, and involves detailed geometric analyses of folds and other geological structures. Examples of real tectonic structures, mostly from North America, are presented in the final portion of the course. Special emphasis is placed on modern techniques of estimating the state of paleostrain in sedimentary and metamorphic rocks, mapping that strain throughout large geological structures, and interpreting patterns of deformation in terms of realistic geomechanical models. (Prerequisite:GLG332F or permission of the instructor)

W.M. Schwerdtner

GLG372H MINERAL IDENTIFICATION LAB.
III-2B - 2 - 6, - 2 - 6
The descriptive mineralogy of some 350 important species, including their hand-specimen identification.

GLG416F FIELD COURSE
IV-2C - - - 12
A two week Field Camp immediately following the conclusion of the annual third year examinations. The first week is in the Toronto area and will include field observation and practice in geotechnical engineering and surveying. The second week will be instruction and experience in geological mapping. A fee currently about $60.00 is charged to cover part of the cost of food and accommodation for the second week.

GLG421Y MINERAL DEPOSITS
IV-2A 2 3 - 12,2 3 - 12
Lectures stress descriptions of important deposits and their geolcgical setting; discussion of ore forming processes, including the application of geochemistry to ore genesis: systematic ore mineralogy. Laboratories are concerned with the identification of ore minerals in polished section using the ore microscope, reflectivity and microhardness equipment, and x-ray powder diffraction. Numerous ore suites are examined and one suite, selected by the student, is studied in detail: all studies of ore suites are oriented towards the problems of milling the ore and the types of concentrates that are likely to be produced.

A.J. Naldrett

GLG425F FIELD CAMP

IV-2A - - - 12

A two-week field camp for students in Option A immediately following the conclusion of the annual Third Year examinations. Instruction and experience in geological mapping. A fee, currently $100.00, is charged to cover part of the costs of meals and accommodation. (Prerequisite: GLG 320Y, 332F, 333S).

Staff

GLG428F PETROLEUM GEOLOGY AND ENERGY RESOURCES

IV-2A 2 3 - 12

Application of geology to exploration for oil and gas and to evaluation of other energy sources within sedimentary basins, namely coal and uranium. Analysis of conditions that influence the use of non-renewable energy resources.

J.E. Currie

GLG480Y EXPLORATION GEOCHEMISTRY

IV-2A 2 3 - 12, 2 3 - 12

Geochemical aspects of mineral exploration, including characterization of target, nature of detectable halos associated with target and typical survey methods. Laboratory study includes field examination of an undeveloped mineral deposit, chemical analysis of materials collected and statistical analysis of the analytical results.

S.E. Kesler, J.C. Van Loon

GLG481Y ORE MINERAL IDENTIFICATION

IV-2B - 3 - 5, - 3 - 5

The laboratory portion of GLG 421Y.

A.J. Naldrett

INSTITUTE FOR THE HISTORY AND PHILOSOPHY OF SCIENCE AND TECHNOLCGY

HPS280F HISTORY OF SCIENCE

1 - 1 12

An introduction to the history of science, using case studies cf the works of such men as Galilec, Newton, and Faraday to illustrate the development of scientific thought and its historical significance.

HPS281F HISTORY OF TECHNOLCGY ANC ENGINEERING UP TO THE INDUSTRIAL REVOLUTION

1 - 1 12

A treatment of the origins cf technology and engineering covering development in the civilizations of the Ancient World, that of Greece and Rome, the Medieval World and the period cf the Renaissance. Emphasis will be placed cn the developments of techniques and of machines with an indication of the context in which these cccur.

HPS282S HISTORY OF TECHNOLOGY AND ENGINEERING FROM THE INDUSTRIAL REVOLUTION TO THE PRESENT

1 - 1 12

A treatment of the development of machines and the utilization of new power scurces during the period under discussion. The interrelation of new techniques and chemical processes with economic and other factcrs as well as the interaction between science and technology will be included.

HPS283S TECHNOLOGY, ENGINEERING AND SOCIETY

1 - 1 12

A social history course which emphasizes the period since the Industrial Revolution. Lectures and readings concentrate on the cultural impact of technology and deal with such topics as technology and democracy, the engineering profession, and the role of government in fcstering or ccntrclling technical development.

DEPARTMENT OF INDUSTRIAL ENGINEERING

IND200S INTRODUCTION TO INDUSTRIAL ENGINEERING II
II-4 2 - 2 12
History of Industrial Engineering. The nature and major components of modern Industrial Engineering. The scientific method - the concepts of induction and deduction. Introduction to management science with special reference to the conceptualization of systems of men and machines, decision-making, criteria of performance, and optimization. The mathematical model and its central role - the classification and utilization of models. Basic characteristics of control systems. The formulation and structuring of typical Industrial Engineering problems.
J.W. Abrams and Staff in Industrial Engineering

IND201F INTRODUCTION TO INDUSTRIAL ENGINEERING I
II-4 2 - 2 12
A broad survey of the principles of productivity management including methods study and work simplification, plant location and facilities planning, value analysis, work measurement, production and inventory control, quality control, resources management and organization theories.
J. Rives

IND202F COMPUTERS AND PROGRAMMING I
II-4 2 - 2 12
Computer organization; machine and assembly language; basic data structures and their applications; fundamental algorithms, computer system architecture; computer program engineering. The course emphasizes the formulation of complete, correct, and efficient algorithms for the solution of problems drawn from engineering, computer science, information processing and operational research. Practical work includes laboratory exercises and program design assignments, involving coding in /370 Assembler and PL/1.
R.W.P. Anderson

IND203S COMPUTERS AND PROGRAMMING II
II-4 2 - 2 12
A continuation of course IND 202F with further emphasis on computer program engineering, covering the following topics: information storage and retrieval, file organization, input/output processing; data structures, list processing; introduction to functions and facilities of operating systems with specific reference to System/370; efficiency; special purpose languages. Problems chosen from engineering, operational research, and data processing, will involve coding in PL/1 and assembler. (Prerequisite: IND 202F or equivalent)
R.W.P. Anderson

IND301F OPERATIONAL RESEARCH I
III-4; IV-5cs, 5e (elective) 1 - 2 12
An introduction, using simplified case studies, to the methodology, techniques and applications of operational research. Emphasis will be placed on developing an understanding of operational research as a rational approach to decision-making. Models to be studied will include ones for decision-making regarding inventory, replacement, allocation, scheduling and project management. The course is presented in a self-paced modular format, without formal lectures. Enrolment limited. (Prerequisite: MAT294S, STA282S/STA292S, exclusion: IND331S)
A.A. Cunningham

IND302S OPERATIONAL RESEARCH II

III-4 2 - 2 12

A continuation of IND 301F with emphasis on problems where more complex models are required. The focus is on the constructive interaction between problem identification and mathematical solution techniques. Models discussed include multi-period and multi-item inventory management, decision analysis, integer programming and dynamic programming. (Prerequisite: IND301F, exclusion: IND331S)

J.S. Rogers

IND304S INDUSTRIAL RELATIONS

III-4 (elective) 2 - 1 12

A discussion of trade unions, labour legislation and the collective bargaining process. (Exclusion: ECO244Y)

A. Kruger

IND305S HUMAN FACTORS IN MAN-MACHINE SYSTEMS

III-4 2 3 - 12

The course will be concerned with Human Factors from two points of view: (a) the anatomical, physiological and psycho-physical factors underlying the design of specific man-machine interfaces in specific environments; (b) the psychological factors involved in the determination of the allocation of function between men and machines in the overall system, specifically information processing capacity, acquisition and retention of skill, adaptability and stress. The laboratory period will illustrate and emphasize experimental methods in these areas.

P.J. Foley, J. Senders

IND306F APPLIED STATISTICAL ANALYSIS

III-4 2 - 2 12

A selection of advanced topics in applied statistics including general regression theory, analysis of variance, and design of industrial and engineering experiments. Applications to cost and productivity analysis, validation of mathematical models, design of experiments in simulation, ergonomics etc. Particular attention will be paid to real situations in which the usual assumptions of statistical theory do not hold.

J.G.C. Templeton

IND307S FUNDAMENTALS OF PRODUCTION

III-4 2 - 2 12

The meaning of production. The economist's and engineer's approach to production; the systems approach. Production as materials processing and information processing. Characteristics of production operations: their energy, space, material yield, environmental, control and scale implications. Classification and analysis of production operations: changes in form, physical and chemical properties, location, measurement. Integration of operations and interfaces between them. Examples from various industries; influence of the production process on industry structure.

J.A. Buzacott

IND308F UTILIZATION OF ENERGY

III-4 2 - 2 12

Sources and utilization of energy; energy storage and transport; principles of energy conversion. Economic, envircnmental and biological issues. The course will provide the foundations for the understanding cf energy production and utilization factors in complex socio-technical systems, with special reference to production systems and related industrial and commercial operations.

J.S. Rogers, R.W.P. Anderson, E.E. Pickett

IND323S THE ANALYSIS OF MAN-MACHINE SYSTEMS

III-5cs;5e (elective) 2 2 - 11

Fundamental principles of design of man-machine interfaces will be introduced in the initial component of the course. The remainder of the course will be concerned with the use of quantitative models of human behavicur which interact with the dynamics of systems. Labcratory and demonstrations. Enrolment limited. (Exclusicns: IND305S, 423S)

J. Senders

IND412S ORGANIZATIONAL THEORY

IV-4 (elective) 2 1 - 12

Study of organizational structures, goals and environment. Organizational growth and change. Managerial and grcup behavicur; problems of leadership, mctivation and satisfaction. Cases and project. Enrolment limited.

M.G. Evans

IND413F FUNDAMENTALS OF MANAGEMENT SCIENCE

IV-4 (elective) 2 - 1.5 12

The ccurse presents the basic principles of decision-making. It includes such cencepts as the changing value of money, the analysis cf data by Bayesian inference, the value of accurate information, the use of cardinal utility to represent aversion to risk, and the expression of individual choice by indifference curves. The concepts are illustrated with industrial applications. (Prerequisite: IND302S)

J.W. Abrams

IND414S APPLICATIONS OF MANAGEMENT SCIENCE

IV-4 (elective) 2 - 1.5 12

Algebraic procedures are presented for applying decision theory tc processes where uncertainly is characterized by binominal, Poisson and normal distributions. Examples include inspection sampling, equipment replacement, marketing and project cost estimation. (Prerequisite: IND 413F)

R. Seal

IND415F PRODUCTION SYSTEMS

IV-4 (elective) 2 - 1.5 12

Introduction to the basic features of production systems and methcds of modelling their operation: the material flcw, information and control systems. Forecasting, inventories, service level and its measurement, periodic and continuous review inventcry models, ABC analysis, aggregate inventcry models. The role of inventories in physical distributicn. Inventories in manufacturing; requirements planning vs order point control. Planning production capacity. Production control and scheduling. Theory and simulation studies in scheduling. (Prerequisite: IND301F)

J.A. Buzacott

IND416S SCHEDULING AND CONTROL
IV-4 (elective) 2 - 1.5 12
Methods of design for operation and control in man-machine systems. Macro-scheduling of manpower and production with discrete and continuous models. Micro-scheduling of jobs and machines. Flow and job shop scheduling. Requirements planning. Demand forecasting and parts explosion for the levels of production. (Prerequisites: IND 302S, 203S, 306F)

I.B. Turksen

IND417F STOCHASTIC MODELS
IV-4 (elective) 2 - 1.5 12
A course on the analysis of stochastic models in operational research. Review of relevant aspects of probability theory; Poisson processes and renewal processes; queueing models and Markov chains; applications to problems in electronic testing, traffic flows, reliability, inventory, etc. (Prequisite: STA292S)

M.J.M. Posner

IND418F SYSTEM SIMULATION
IV-4 (elective) 2 - 1.5 12
Computer simulation of systems. Design of continuous and discrete simulation models. Statistical foundations and methodology. Generation of random variates. Design of simulation experiments. Simulation programming languages. Applications: the analysis and design of systems for production, distribution, health care, education, and information. (Prerequisites: IND 302S, 203S, 306F)

I.B. Turksen

IND419S INFORMATION AND OPTIMIZATION
IV-4 (elective) 2 - 1.5 12
Efficient transmission of information, coding of messages, capacity of an information channel, error-correcting codes; applications to practical communication systems. Unconstrained optimization in n dimensions: classical and modern algorithms; applications to non-linear programming. (Prerequisite: CSC 381F)

J.G.C. Templeton

IND420S MATHEMATICAL PROGRAMMING
IV-4 (elective) 2 - 1.5 12
Formulation of the linear programming problem, the simplex method (review), the revised simplex method, duality and the dual simplex method, postoptimality problems, parametric linear programming. Transportation problems, the fixed charge problem. Flows in networks. Integer linear programming, algorithms for the all-integer and the mixed integer-continuous problem. Fractional linear programming. (Prerequisite: IND 302S)

J. Abrham

IND421F MANAGEMENT INFORMATION SYSTEMS
IV-4 (elective) 2 - 1.5 12
Study of information systems in relation to both operational and decision-making activities in an organization; special attention to management planning and control activities. Models of information systems; manpower, logistics, and financial subsystems. Integrated systems. The roles of the information analyst and systems designer; the information processing organization; user implications. The development cycle of information processing systems; project control, implementation, and evaluation. Case studies and projects. (Prerequisite: IND 203S)

S.H. Cohn

IND423S HUMAN PERFORMANCE IN MAN-MACHINE SYSTEMS

IV-4 (elective) 2 3 - 12

The course will cover theoretical and empirical aspects of human performance capabilities in information processing, decision making and control processes, and the loads imposed on the human operator by such tasks. The laboratory will stress the testing and validation of theories and models of human performance and work load measurement. Enrolment limited. (Prerequisite: IND305S)

J. Senders

IND424F HUMAN INFORMATION PROCESSING IN MAN-MACHINE SYSTEMS

IV-4 (elective) 2 3 - 12

An examination of Human Information Processing, with particular attention to the nature of biological coding mechanisms; the organization of sensory and perceptual processes; attention and vigilance; the structure and functional limitations of symbolic processes and language. Enrolment limited (Prerequisite: IND305S)

P.J. Foley

IND425S DYNAMICS OF GENERAL SYSTEMS

IV-4 (elective) 2 - 1.5 12

Development of dynamic models using state space representation for planning and control of industrial, environmental, economic, and social processes. Parameter identification and control methods will be used to study the implications of growth, stability, productivity, energy transfer, and community organization on such systems along with certain topics in population dynamics and adaptive control mechanisms in changing environments. (Prerequisites: MAT294S, MEC357S, recommended: APM391F)

E.E. Pickett

IND426S ORGANIZATIONAL BEHAVIOUR

IV (elective) - 5 - 12

Individual and group behaviour in work organizations. Relevance to human behaviour and management problems, supervision, communications, motivation and implementation of change. The laboratory will emphasize the interaction among people in problem-solving situations, while performing the dual role of employee/professional. Enrolment limited. (Exclusion: IND 412S)

R.C. Whitney

IND499Y THESIS

IV-4 - 6 - 12, - 6 - 12

Design and analysis of an engineering system to satisfy specified objectives and requirements. This project, extending over two terms, will provide the student with an opportunity to apply the knowledge and techniques of analysis acquired in his other Industrial Engineering subjects. The work will be carried out by students working in small groups, or individually, under the supervision of staff members.

Staff in Industrial Engineering

DEPARTMENT OF MATHEMATICS

MAT185S LINEAR ALGEBRA
I-5 3 - 1 12
Matrix algebra, applications to network problems. Gauss-Jordan method for solving simultaneous linear equations. The rank of a rectangular matrix, the dimension of the vector space of solutions to a homogeneous equation, and the existence and uniqueness of solutions to simultaneous linear equations. Geometric properties of 2 x 2 determinants, definition and basic properties of n x n determinants, Cramer's Rule. Eigenvalues and eigenvectors with application to vibration problems and the simplification of quadratic forms.

MAT186F CALCULUS I
I-1,2,3,4,6,7,8 2 - 2 9
Limits, differentiation, maximum and minimum problems, definite and indefinite integrals, fundamental theorem, and applications including areas, volumes, moments, pressure and work, logarithm and inverse trigonometric functions.
Staff in Mathematics and Staff in Engineering

MAT187S CALCULUS II
I-1,2,3,4,6,7,8 2 - 2 10
Elementary functions, techniques of integration, vector differentiation, series, differential equations.
Staff in Mathematics and Staff in Engineering

MAT188F Algebra I
I-1,2,3,4,6,7,8 2 - 2 9
Linearity, vectors, geometry of lines and planes, complex numbers, linear transformations, matrices, determinants, inverse of a matrix, scalar product.
Staff in Mathematics and Staff in Engineering

MAT189S ALGEBRA II
I-1,2,3,4,6,7,8 2 - 2 10
Quadratic forms, orthogonal transformations, eigenvalues, eigenvectors, linear programming.
Staff in Mathematics and Staff in Engineering

MAT194F CALCULUS I
I-5 3 - 2 12
Theory and applications of differential and integral calculus, limits, basic theorems, elementary functions.

MAT195S CALCULUS II
I-5 3 - 1 12
Techniques of integration, improper integrals, sequences, series, Taylor's theorem, differential equations, functions of several variables and partial derivatives.

MAT 280F CALCULUS
II-1,6 3 - 2 13
Partial differentiation, directional derivatives, tangent plane and normal line, maxima and minima, Lagrange multipliers, higher order derivatives, exact differentials. Multiple integrals, area, volume, moments, cylindrical and spherical coordinates, surface area. Series expansion of functions. First order differential equations. (Exclusion: MAT 294S)

MAT289S COMPLEX VARIABLES
II-5 3 - .5 12
Complex plane analytic functions, Cauchy's theorem, Taylor and Laurent series, singularities, analytic continuation, contour integration, conformal mapping, and applications.

MAT290F DIFFERENTIAL EQUATIONS
II-7 3 - 2 12
Linear ordinary differential equations and systems, series, transform and numerical solutions, nonlinear equations, Frobenius' method and series solutions, introduction to partial differential equations.

MAT293F CALCULUS
II-2,3,4,8 2 - 2 12
Functions, of several variables, partial differentiation, maximum and minimum problems, Taylor series, multiple integrals, area and volume, line integrals, Stokes' theorem. (Prerequisite: MAT186F, MAT187S)

MAT294S CALCULUS AND DIFFERENTIAL EQUATIONS
II-2,4,8 2 - 2 12
Multiple integrals, area, volume, moments, cylindrical and spherical coordinates, surface area, line integrals. First and second order differential equations. Linear differential equations with constant coefficients. Linear systems. Matrix methods. Vibrations.

MAT295F CALCULUS III
II-5 3 - 1 12
Convergence and uniform convergence, Fourier series, Legendre and Bessel functions, coordinate transformations, multiple integrals, line and surface integrals, orthogonal functions.

MAT490F LINEAR ALGEBRA AND APPLICATIONS
IV-5 (elective) 3 - - 12
The concepts of vector space, inner product space, linear map and determinant will be reviewed; the structure of a linear transformation (invariant subspaces and eigenvalues); tensors. The latter part of the course will treat a selection of applications such as Hilbert spaces, differential equations, control processes, stochastic processes.

DEPARTMENT OF MECHANICAL ENGINEERING

MEC201S DYNAMICS I
II-3 3 - 1.5 12
Calculus of vectors. Kinematics of bodies in rectilinear and curvilinear translation, rotation, and general motion. Spacecraft orbits. Impulse, momentum and moment of linear momentum. Conservative systems. Work-energy relations. Dynamics of motion. Euler's equations. Gyroscopic mechanics. Plane motion. D'Alembert's principle. Virtual work. Introduction to generalized co-ordinates, degrees of freedom, Lagrange equations. Introduction to mechanical vibrations and balancing.

MEC205F DYNAMICS
II-7 2 - 1 8
Kinematics of particles using Cartesian, space curve and cylindrical coordinates units. Dynamics of particles by momentum and energy methods. Kinematics and dynamics of rigid bodies. Mechanical vibrations. Text: Vector Mechanics for Engineers - Statics and Dynamics, Berr and Johnston, McGraw Hill, 1972.

MEC211F MECHANICS OF SOLIDS I
II-3 3 1.5 1.5 12
Definition of stress and strain at a point. Linear stress strain (plane stress and plane strain). Principal stresses and strains; transformation of stress and strain;Mohr's method of analysis. Shearing stresses and deformations in circular shafts and thin walled hollow members. Bending and shearing stresses in beams; differential equations of equilibrium; singularity functions. Deflection of beams; buckling of columns. Thin shells of revolution. Properties of mechanical engineering materials.

MEC212S MECHANICS OF SOLIDS II
II-3 3 - 1.5 12
Compound stresses, superposition. Experimental stress analysis methods (photoelasticity,strain gauging,brittle lacquer). Fatigue, yield and fracture criteria for engineering materials; stress concentrations. Design of members to meet strength requirements in engineering applications; torsion members, prismatic and non-prismatics beams, complex members, columns, thin shells and springs. Statically indeterminate problems. Energy methods of solution. Generalised equilibrium and compatibility relationships with application to thick cylindrical pressure vessels and rotating discs.

MEC261F DIFFERENTIAL EQUATIONS
II-3 3 - 3 12
First-order equations. Second-order equations. Operator techniques. Systems of equations. Power series for variable-coefficient equations. Numerical techniques.

MEC265S METROLOGY
II-3 2 1.5 1.5 12
Nature of experimental error, its minimization and response characteristics of physical systems. Emphasis is on probability, statistical analysis of experimental data, principles of quality control and design of experiments. Topics to be covered include evaluation of random processes and computer techniques for statistical treatment of continuous data; case studies and discussion of selected mechanical measurements.

MEC303S VIBRATIONS

III-3 3 1 2 12

Systems modelling and analysis. Analysis of single degree of freedom systems. Various types of damping forces. Vibration isolation. Vibration measuring instruments. Steady state and transient vibrations. Vibration of multi-degree of freedom systems. Analog and digital computer solution methods. Numerical methods of frequency analysis. Lagrange equations and Hamilton's principle. Energy methods. Vibration of strings, beams and plates.

MEC315S STRESS ANALYSIS

III-5nt 3 - 1 12

Definition of stress and strain at a point in a continuum; Derivation of equilibrium and compatability relations; Use of stress functions and energy methods in stress analysis; Application to beams, plates, shells, pressure vessels and rotating discs; Fatigue failures; Introduction to finite element techniques: Experimental methods namely, photoelasticity, strain gauging and brittle coatings.

MEC321F THERMODYNAMICS I

III-3 3 1.5 1.5 15

Thermodynamic states of simple systems; the fundamental relation of thermodynamics; the first law of thermodynamics; the entropy postulates; equilibrium; PVT-diagrams, equations of state, compressibility charts and steam tables; calculation of property changes, enthalpy, Helmholtz and Gibbs function, the Maxwell equations; applications of thermodynamics, cycles, reversibility; thermodynamics of phase changes, the Clapeyron equation, Gibbs phase rule; the fundamental structure of thermodynamics, the Euler equation, the Gibbs-Duhem equation and Legendre transformers.

MEC322S THERMAL ENERGY CONVERSION

III-3 3 3 - 12

The application of thermodynamics to the analysis and design of heat engines, refrigerators and processes associated with useful energy transformations; engine and turbine cycles for vapours and gases; combustion processes; psychrometry and air conditioning; consequences of thermodynamic potential and availability considerations in direct energy conversion devices.

MEC324S THERMAL ENVIRONMENT ENGINEERING

III-3,IV-3 (elective) 3 1.5 1.5 12

Psychrometrics, heating and cooling. Refrigeration including vapour compression, absorption and thermoelectric devices. Solar radiation. Design and applications to the control of environmental systems in residential, public and industrial buildings and processes. Computer-aided design procedures. (NOT OFFERED 1977-78)

MEC327F HEAT ENGINEERING

III-5nt; III-5a (elective) 2 3 - 12

The concepts of engineering thermodynamics as they relate to energy conversion processes. Vapour power cycles using fossil and nuclear fuels. Gas power cycles, internal and external combustion engines and turbines. Gas compression, refrigeration and psychrometry. Combustion of fuels. Direct energy conversion and the potential for new systems.

MEC341F FLUID MECHANICS I

III-3 3 1.5 1.5 15

Introductory concepts, fluid properties and definitions. Hydrostatics, Pascall and Euler thecrems, hydrostatic stability. Kinematics and dynamics of the flow, Eulerian and Lagrangian coordinates, continuity, energy and mcmentum equations. Irrotational flow, velocity potential, stream functicn. Stress systems for a viscous fluid, Cauchy's equation, Navier-Stokes equations. Viscous, laminar flow. Turbulent flow, Reynolds equaticns. Boundary layer theory, internal and external flows.

MEC349S TRANSPORT PHENOMENA

III-8;III-5g (elective) 3 1.5 1.5 12

A study of the forces and motion produced by various fluid prcperties. Gravitational, viscous and inertial forces are considered in detail. Mcmentum, energy and continuity relation, boundary-layer apprcximaticn, turbulence, flow in pipes and arcund submerged bodies. Steady-state ccnductien in one dimension; extended surfaces; heat conduction with two or mcre independent variables; forced convection and dimensional analysis; heat transfer by free convecticn; radiant heat transfer; heat transfer by ccmbined ccnduction and convection; heat transfer in liquid metals.

MEC351F FLUID MECHANICS

III-1,2C 3 1.5 - 12

Introductien: fluid and flow characteristics dimensions and units. Fluid statics: fundamental equaticn, gravity and inertia action, engineering applicatiens. Fundamentals of cne-dimensional flow: ccnservation principles of mass, energy and momentum, applications to ideal-fluid flow. Dimensional analysis and similitude. Fundamental concepts of real fluid flow: laminar and turbulent flow, boundary layer concept, flow about immersed cbjects. Flow in clcsed conduits: flcw development, friction lcss, minor lcss, typical pipe-flow problems. Flow in open channels: uniform flow, varied flow. Special topics of interest to civil engineers. Tutorials, films and experiments complementing lecture material.

MEC354F FLUID MECHANICS

III-5c,5nt 3 1.5 1.5 12

A fundamental approach to the mechanics of fluid mction. Continuum concepts. Kinematics and dynamics of flcw. Irrotational motion. Vcrticity. Laminar flow solutions. Turbulent motions. Applicaticns to ccnduit flow. Free surface waves. Fluid machinery.

MEC357S CONTROL ENGINEERING

III-4 2 1 1 12

Introduction to the dynamic behaviour cf linear systems. The feedback principles. Stability and response of linear control system. The convolutien theory. Transfer functions of linear systems. Analysis and design of linear control system introduction to servomechanism technology for ccntrol system design. Problems and labcratory experiments will accompany the lectures. (Prerequisite: MAT 294S).

MEC358S CONTROL SYSTEMS

III-5nt 3 1.5 1 12

Analysis and synthesis of linear feedback systems by frequency response methcds and the root locus technique. Analysis of physical systems by state space techniques. Introduction to nonlinear and optimal control systems. Digital computer control. Multivariable feedback system design. Techniques will be illustrated by application to models of CANDU nuclear power stations.

MEC362F ENGINEERING ANALYSIS I
III-3 3 - 3 15
Analytical techniques include Laplace transforms, series solutions of ordinary differential equations, special functions, vector calculus.

MEC363S ENGINEERING ANALYSIS II
III-3 2 - 1.5 12
Ordinary linear differential equations of second order, Sturm-Liouville theory and expansions in orthogonal functions. Higher-dimensional calculus and introduction to partial differential equations. Method of characteristics, separation of variables and integral transform methods of solution with application to problems of fluid flow, heat transfer and structural deformation.

MEC371F ANALYSIS AND DESIGN OF MECHANISMS
III-3 3 - 3 15
Types of mechanisms; analysis and design to meet functional requirements of positioning, force application and energy transmission. Synthesis and analysis of linkages, cams, and gears. Hydraulic actuators. Design for dynamic loading and energy storage. Springs and flywheels. Load capacity of bearings and gears. Stress concentration factors.

MEC375S ANALYSIS OF MACHINING PROCESSES
III-3,IV-3 (elective) 3 1.5 1.5 12
Machine tools and machining operations. Mechanics of machining. Temperatures in metal cutting. Tool wear, tool life. Cutting fluids. Machinability. Surface roughness. Economics of machining. Machine tool vibration. Numerical and adaptive control of machines tools. Modern machining : ultrasonic, electrochemical and electric-discharge machining. (NOT OFFERED 1977-78)

MEC376S ANALYSIS OF FORMING PROCESSES
III-3,IV-3 (elective) 3 1.5 1.5 12
Introduction to plasticity. Upper and lower bound theorems. The slip-line field theory. Hot and cold forming. Drawings. Tube making. Deep drawing. Extrusion. Rolling. Forging. Friction and lubrication in metalworking. Temperature distribution. Explosive forming. Powder metallurgy. Foundry processes. Polymer forming including compression, injection, blow and rotational moulding; vacuum forming.

MEC381S BIOMECHANICAL ENGINEERING
III-3,IV-3 (elective) 3 1.5 1.5 12
Apsects of fluid flow, surface chemistry, thermodynamics and solid mechanics related specifically to biomedical situations; case studies involving the above problems.

MEC413F MECHANICS OF SOLIDS III
IV-3 2 - 1.5 12
Stress and strain tensors and generalization of constitutive equations. Extension to orthotropic material constants. Equations of equilibrium and compatibility. Solution procedure using displacements and stress functions. Illustration of the theory by application to beams, plates, rotating discs, thick composite cylinders, torsion of non circular sections. Elastic instability. Fracture mechanics. Introduction to finite difference and finite element methods of solution.

MEC426S STATISTICAL THERMODYNAMICS
III-5nt,5p 3 1.5 - 15
The idea of ensemble averages is used to develop the expression for the fundamental relations of thermodynamics in terms of molecular properties; partition functions for the ideal monatomic crystal, the ideal monatomic gas and black body radiation are developed. A molecular interpretation of entropy is developed and fluctuations about an equilibrium state are discussed along the ergodic hypothesis and rate processes.

MEC427S DIRECT ENERGY CONVERSION
IV-3 (elective) 2 1.5 1.5 12
Topics from non-equilibrium thermodynamics and the thermal properties of semi-conducting materials are discussed. Application of these ideas is made to energy conversion devices such as themoelectric generators, solar cells and electrochemical cells. Alternative systems and energy storage problems are considered.

MEC428F ENERGY CONVERSION
IV-5nt 3 3 - 12
The theory of fluctuations and the Onsager principle are discussed. Irreversible thermodynamics is developed and used to analyse direct energy conversion devices. Thermoelectric processes such as the Seebeck, Peltier, and Thomson effect are considered and systems such as fuel cells, thermoelectric, thermionic, and magnetohydrodynamic generators are analysed.

MEC429F ENERGY SYSTEMS ANALYSIS
IV-5nt (elective) 2 - 1 10
The concepts of systems analysis are developed as they apply to complex energy conversion aapplications. The interactions between the elements of such systems are explored. Methods of approach to the selection of energy sources, of energy storage, of energy conversion systems and of operating strategies in relation to economic, ecologic, and community priorities are reviewed. Techniques for optimization are introduced. Actual case studies are drawn from such areas as solar space heating, vehicle propulsion, nuclear and fossil fuelled power generation and distribution systems, and the integration of power generation, incineration and district heating functions in combined systems.

MEC431F HEAT AND MASS TRANSFER
IV-3 3 1.5 1.5 12
Steady state and transient conduction; surface and gas radiation; convective heat and mass transfer under laminar and turbulent flow conditions in pipes, and over flat plates; free convection from plates and in plumes; dispersion of heat; boiling and condensation; application to the design of heat transfer equipment.

MEC433S HEAT TRANSFER
IV-5nt 2 - 2 12
Steady state and transient conduction, surface and gas radiation, convection, boiling, condensation and combined mechanisms. Special attention is given to analogue and computational procedures and to consideration of the manner in which novel or complex problems may be approached.

MEC443S APPLIED FLUID MECHANICS
IV-3 3 3 - 12
Study of one-dimensional gas dynamics encountered in Engineering practice including nozzle flows, friction, heating and normal shock waves. Water hammer and design procedures for alleviation, hydraulic transients in pipe system. Design principles and operational characteristics of flow machines, primarily turbo-machines. Lift and drag on submerged bodies and application to flow-induced vibrations. Dispersion of air pollution and concepts of pollution control.

MEC444S ENVIRONMENTAL POLLUTION AND CONTROL
IV-3 (elective) 3 1.5 1.5 12
Identification of serious environmental pollutants; analysis of short and long term effects upon the ecology; dispersion of contaminants in meteorological, limnological and oceanographic situations; techniques for tracing and measuring contaminant levels; control of effluent via precipitators, scrubbers, filters, etc. sociological and economic implications.

MEC452S HYDRAULIC ENGINEERING
IV-1,2C (elective) 3 2 - 12
Review of flow principles. Techniques of field measurement. Open channel and closed circuit flow. Hydraulic structures and appurtenances, transitions, controls; dams; navigation works; methods of construction. Hydraulic machinery, pumps, turbines, power and control systems. Design and testing of hydraulic engineering sytems; analytical procedures, numerical methods and computer simulation. Systems analysis.

MEC455F CONTROL SYSTEMS I
IV-3 3 1.5 1.5 12
Analysis and synthesis of linear feedback systems by frequency response methods and the rootlocus technique. Introductions to nonlinear control systems, the statespace tenchnique, and digital computer control.

MEC472S DESIGN
IV-3 2 - 3 12
Decision theory and methods of design synthesis will be presented and appraised in terms of the utility, the design variables and the constraining conditions imposed or associate with a given design. These concepts will be combines with various elements of mechanical engineering to illustrate design topics such as optimisation, simulation and reliability. Several short design projects of this nature will be undertaken in which the student will be encouraged to utilise the the computer and other related software as efficient and practical design tools.

MEC499Y THESIS
IV-3 - - - 12, - - - 12
The thesis may consist of one of the following: 1. Group design projects: Large projects covering a broad range of mechanical engineering will be offered. The projects will refer to realistic situations and contribute to the solution of the design problem, i.e. individuals will specialize in the various aspects of the design. 2. Individual research and design projects: With the approval of the thesis coordinator and a supervising professor a student may perform original research, experimentation, or specialized design. 3. Interdisciplinary group design: The interdisciplinary group design course CED 401 may be taken in lieu of MEC 499. Full details of the thesis-project requirements are available on request from the Departmental Office.

MEC1001F DYNAMICS II
IV-3 (elective) 2 1.5 1.5 15
Review of particles and rigid body kinematics and techniques for formulation of equations of motion; central force dynamics; gyrodynamics; stability of dynamic systems; dynamic stresses, random excitation and dynamic test; special topics.

MEC1050F PRINCIPLES OF MEASUREMENT
IV-3 (elective) 2 1.5 1.5 15
Design of experiment; uncertainty analysis and minimization of errors; discussion of physical principles underlying the design of mechanical, optical and electronic instruments and transducers; analogue and digital data recording and processing; data evaluation; random processes, spectra and correlation techniques.

MEC1101F THERMODYNAMICS II
IV-3 (elective) 2 1.5 1.5 15
The postulatory approach to thermodynamics is developed. The conditions for equilibrium of systems under different constraints are considered. Systems undergoing phase transitions, elastic systems and the thermodynamics of surfaces are considered. The postulates are generalized to include non-equilibrium thermodynamics. Topics such as entropy production, generalized foces and fluxes, and the Onsager coefficients are discussed.

MEC1201F FLUID MECHANICS II
IV-3 (elective) 2 1.5 1.5 15
Kinematics of fluid motion; equation of continuity, stream functions, circulation and vorticity. Dynamics of ideal flow fundamental equations, fluids at rest, filament flow, potential flow. Dynamics of real fluid flow: fundamental equations, similitude, exact solutions, creeping flow, boundary layers. Turbulent flow: general features, wall turbulence, free turbulence. Diffusion and convection problems.

MEC1303S CONTROL SYSTEMS II
IV-3 (elective) 2 1.5 1.5 15
A detailed case study of modelling, analysis, and design of a electrohydraulic servo mechanism. The analysis and design of multivariable feedback systems based on state-space techniques. Case studies of (computer) control of multivariable systems, with emphasis on conventional and nuclear power generation.

MEC1402S ENGINEERING ANALYSIS IV
IV-5 (elective) 2 - - 15
The emphasis in this course is on the solution to engineering problems which are governed by nonlinear ordinary or partial differential equations. Some exact methods of solutions and some approximate methods are treated. Specific exact-solution methods considered include group invariants and similarity solutions. The approximate methods include perturbation techniques, singular perturbation, the removal of singularities by the method of matched asymptotic expansions and the method of two-time scales. These methods are applied to the solution of problems in non-linear vibration, heat conduction and fluid flow.

DEPARTMENT OF METALLURGY AND MATERIALS SCIENCE

MMS100S INTRODUCTION TO METALS
I-1,2,3,4,5,6,7,8 (elective) 3 1.5 - 12
An introduction to the role of metals in the growth of the modern industrial society. The role of metal production in the Canadian economy, methods of extraction and fabrication of metals, and the effective utilization of metals will be discussed. In addition to laboratory experiments illustrating the determination of structure and properties of metals, the student will participate in a four-week project under the direct supervision of a professor. The project will enable the student to design and carry through studies of particular aspects of metal extraction and application.
The projects include:
Physical Metallurgy (Prof. Aust)
Solidification of Eutectic Alloys (Prof. Miller)
Fracture and Failure Analysis (Prof. Ramaswami)
Differential Thermal Analysis Prof. Toguri)
Beneficiation and Recovery of Iron Ores (Prof. Ross)
Production of Metallic Copper (Prof. McAndrew)
Freezing of Transparent Analoques of Metal Alloys (Prof. Rutter)
Electrolytic Recovery of Metals (Prof. Flengas)
Chemical Reactions in Iron and Steelmaking (Prof. McLean)
Staff in Metallurgy and Materials Science

MMS201F STRUCTURE OF MATERIALS AND METALLOGRAPHY
II-8 2 3 1 12
A course dealing with both the theoretical interpretation and the experimental determination of the structure of solids. Structure is discussed at various levels, viz. macrostructure, single phase microstructures, phase equilibria and binary phase diagrams, equilibrium and non-equilibrium two phase microstructures and crystal structure. Metallographic techniques for the determination of microstructure by optical, x-ray and electron microscopy are considered, as are quantitative metallography and the introductory principles of x-ray diffraction.
W.A. Miller

MMS202F METALLURGICAL THERMODYNAMICS I
II-8 2 - 3 12
The physical - chemical properties of matter. Ideal and real gases, liquids, solids. Heat capacity theory and Debye's law. Calculations of enthalpy, entropy and of free energy for pure materials. First and second order transitions. Chemical equilibria. Heterogeneous reactions - Ellingham diagrams. Activities and other partial molar properties. Experimental techniques for thermodynamic measurements. (Prerequisite: MAT 186F).
S.N. Flengas

MMS203S METALLURGICAL THERMODYNAMICS II
II-8 2 - 3 12
Chemical equilibria at high temperatures in extractive metallurgy. Slag-metal reactions - Order-disorder phenomena - Theory of solutions. Partial molar properties and Thermodynamic relationships in phase diagrams - Ternary solutions - Analytical and graphical solutions of the Gibbs-Duhem relationships. Standard States for the evaluation of partial molar properties and conversions. Solubility of gases in liquids. Phase diagram relationships in Metallurgical Systems. Binary and Ternary Systems.
S.N. Flengas, J.M. Toguri

MMS204S MATERIALS CHEMISTRY

II-8 2 - 2 10

Elementary crystal chemistry, co-ordination numbers, radius ratio. The Born-Haber cycle for ionic compounds and replacement reactions. Point defects, non-stoichiometry and conductivity. The Schroedinger equation and its solution in terms of orbitals. Bonding and physical properties of metals and alloys, and covalently - bonded solids. Inorganic and organic polymers.

C.B. Alcock

MMS205S MATERIALS SCIENCE

II-8 2 - 2 10

A course on the structure and properties of plastics, glass and ceramics. The course discusses the relationship between the microstructure and physical and mechanical properties of non-metallic materials.

G.C. Weatherly

MMS222F MATERIALS SCIENCE AND ENGINEERING

II-4 2 1.5 1 12

The course deals with the basic principles necessary for the selection of engineering materials and for an understanding of their service behaviour. Fundamentals which provide a common basis for understanding the relationship between the structure and the properties of materials will be emphasized.

G.B. Craig

MMS223S MATERIALS SCIENCE

II-3 3 1.5 - 12

The effect of microscopic and atomic structures on the properties of engineering materials. The topics covered include atomic bonding and structures of materials, diffusion, crystal growth and solidification, plastic deformation and annealing, precipitation hardening, phase transformations especially in ferrous materials, relationships between structures and mechnical properties of metallic and non-metallic materials, and composite materials. The laboratory experiments are designed to illustrate the principles underlying the relationship between structures and properties of engineering materials. (Exclusions: MMS 221F, 222F, 250S)

K.T. Aust

MMS226S MINERAL CHEMISTRY

II-2 3 - 1 12

A review of physical chemistry principles with particular reference to mineral and metal systems of interest in geochemistry and mineral processing. Introduction to inorganic chemistry and the descriptive chemistry of the elements and their compounds.

R.T. McAndrew

MMS228S METALLURGICAL ANALYTICAL CHEMISTRY LABORATORY

II-8; III-2B - 3 - 5

A laboratory course designed to illustrate the principles and practice of analytical chemistry. Instrumental and classical wet chemical methods are used to analyze ores, concentrates, slags and alloys. (prerequisite: MMS226S or corequisite MMS204S)

R.T. McAndrew

MMS250S MATERIALS SCIENCE

II-5 (elective) 2 1.5 - 12

The effect of atomic structure, crystal structure, and microstructure on the physical, chemical and mechanical properties of solid materials. Representative examples of metals, ionic crystals, semiconductors, and inorganic compounds will be used to illustrate the principles of materials science. The laboratory experiments complement the lectures and demonstrate the methods and techniques of materials science. (Exclusions:MMS221F, 222F, 223S)

B. Ramaswami

MMS270F MATERIAL SCIENCE

II-7 3 1.5 - 12

Part I of this course deals with the structure of materials in terms of atomic bonding, crystal structure, defect structure and microstructure; with the relationship between structure and properties; and with processes for structure control. Topics discussed include the kinetics of solid state diffusion, with application to semiconductors; phase equilibria; phase transformations, with application to the purification of materials and to the grouwth of single crystals. Part II deals with the electrical, magnetic and dielectric properties of materials. Topics discussed include: electron energy levels in solids; electron transport properties of solids; magnetic properties and their measurement; ferromagnetic domain structure; hard and soft magnetic materials; dielectric properties and dielectric materials. Recent device applications of materials will be discussed.

U.M. Franklin and J.W. Rutter

MMS301F MINERAL PROCESSING I

III-8,2B 2 3 1 12

The theory and practice of mineral beneficiation including particle size measurement, comminution, sizing, liquid-solid separation and ore concentration by gravity, magnetic methods and flotation. The course also includes the relevant aspects of mineralogy, surface chemistry and the movement of solid particles in liquid media. Experiments designed to illustrate the lecture material are carried out in the laboratory while related problems are studied in the tutorial periods.

H.U. Ross

MMS302F ELECTROCHEMICAL AND KINETIC PROCESSES

III-8;IV-2B(elective) 2 - 4 12

Electrochemistry of solids, liquids and of high temperature systems - e.m.f. series - Fused salt electrochemical cells - Thermodynamics of imperfections and properties of ionic solids. Non-stoichiometric oxides, sulfides and carbides. Non-ionic conductivity mechanisms in solids. Fuel cells. Corrosion reactions in aqueous solutions and fused salts. Irreversible electrode reactions - Overvoltage. Kinetics of Heterogeneous reactions. Diffusion controlled processes. Fick's law of diffusion. Application of theory to metallurgical operations.

S.N. Flengas, J.M. Toguri

MMS303S PHYSICAL METALLURGY II

III-5m,8 3 3 - 12

An introduction to the fundamental basis of microstructure control stressing the importance of alloying, plastic deformation and annealing. The principles of soldification, crystal growth, and phase transformations in solids are considered in detail. (Prerequisite: MMS304F)

U.M. Franklin, G.B. Craig, J.W. Rutter

MMS304F PHYSICAL METALLURGY I

III-5m,8 3 3 - 12

Plastic deformation and mechanical properties are discussed in terms of dislocation theory. The annealing processes of recovery, recrystallization and grain growth and the structure and properties of interfaces in materials are also considered. (Prerequisite MMS201F, co-requisite MMS333F for those without MMS201F).

K.T. Aust, W.A. Miller, B. Ramaswami

MMS305S EXTRACTIVE METALLURGY I

III-2B, 8;III-5m (elective) 3 3 1 14

Ferrous Metallurgy: thermodynamic and kinetic aspects; principles of iron making; blast furnace and other reduction process. Hydrometallurgy: introduction to theory and practice of metal production from ores and concentrates by chemical reaction in aqueous solutions. Extractive Metallurgy Laboratory: experiments related to the extraction of metals, and problems on heat and mass transfer.

R.T. McAndrew, A. McLean and H.U. Ross

MMS306F METALLURGICAL THERMODYNAMICS

III-5m 2 - 4 12

A study of chemical equilibria at high temperatures in metallurgy; slag-metal reactions; chemical theory of solutions; alloys; phase transformations; thermodynamic relationships in phase diagrams; statistical concept of entropy; simple partition functions; quasichemical approach to the theory of solutions; methods of investigating thermodynamic properties.

S.N. Flengas, A. McLean

MMS307S MATERIALS SCIENCE

III-5m 3 - - 12

The course discusses the relationship between the structure and properties of glasses, ceramics and polymers. Particular topics discussed are: phase diagrams in ceramic systems; structure of ceramics and glasses; glass - crystal transformation;structure of polymers diffusion;sintering of ceramics; elastic and plastic properties; viscous flow of glasses and polymers; fracture and thermal shock resistance.

G.C. Weatherly

MMS308F CERAMIC MATERIALS

III-8 2 - 2 12

The practical application of ceramics in high temperature corrosive environments. Topics to be discussed include transport phenomena in ceramics, corrosion resistance, thermal shock resistance and mechanical strength. Ceramic coatings. Refractories.

C.B. Alcock, G.C. Weatherly

MMS309F MINERALS EQUILIBRIA

III-2B 3 - 2 12

The methods and formulations of thermodynamics will be discussed on the basis of the three laws of thermodynamics. Phase equilibria diagrams will be presented for one, two and three component systems and equilibria criteria will be examined for simple mineral systems.

A. McLean, J.M. Toguri

MMS311S SURFACE PROPERTIES OF MATERIALS

III-2B,8;III-5m (elective) 2 - 1 10

Thermodynamic treatment of interfaces. Gibbs' adsorption theorem. Structure of liquid surfaces. Adsorption of gases on solids. Dispersion and electrokinetic phenomena.

S.N. Flengas

Topics related to surface properties applicable to mineral processing, such as wettability, contact angles, adsorption, flotation, coagulation, flocculation and dispersion. The Zeta potential of mineral particles in aqueous suspensions is examined in detail.

H.U. Ross

Surface tension, surface stress and surface free energy in solids. Broken bond model calculations of surface energy in solids. Internal interfaces in solids. Anisotropy. Equilibrium approach to processes such as grain growth, spheroidization, particle coarsening and sintering. Role of interfaces in phase transformation and fracture in solids.

A. Miller

MMS312S METALLURGICAL CHEMISTRY

III-5m 3 - 4 14

Chemical equilibria at high temperatures in extractive metallurgy. Slagmetal reactions - Order -disorder phenomena - Theory of solutions. Partial solar properties and Thermodynamic relationships in phase diagrams - Ternary solutions - Analytical and graphical solutions of the Gibbs-Duhem relationships. Standard Sates for the evaluation of partial molar properties and conversions. Solubility of gases in liquids. Phase diagram relationships in Metallurgical Systems. Binary and Ternary Systems. Application of thermodynamic concepts to the theory of steelmaking.

S.N. Flengas, J.M. Toguri, A. McLean

MMS333F STRUCTURE OF MATERIALS

III-5m 2 2 - 12

The structure of solids is treated in tutorial sessions and laboratory projects. Subjects covered include crystallography, phase equilibria, binary phase diagrams and microstructure of materials.

W.A. Miller

MMS401F EXTRACTIVE METALLURGY II

IV-8,2B; IV-5m (elective) 3 1.5 2 13

Acid and basic steelmaking processes; thermodynamic and kinetic considerations pertaining to gas/slag/metal reactions; oxidation, deoxidation and reoxidation reactions; chemical aspects concerning the behaviour of carbon, chromium, sulphur, phosphorus, nitrogen and hydrogen in steel. Production of non-ferrous metals from their concentrates, with emphasis on metals produced in Canada. A fundamental treatment of the oxidation of sulphides in the liquid and solid states, reduction of oxides and chlorides, matte-slag and metal-slag equilibria and kinetics. (Prerequisite: MMS305S)

A. McLean, J.M. Toguri

MMS402F SOLID STATE SCIENCE

IV-5m;IV-8 (elective) 3 1.5 1 12

The course deals with relationships between crystal structure and the electronic and magnetic properties of solids, as well as the formation and stability of alloy phases and intermetallic compounds. The laboratory will be devoted mainly to x-ray and electron techniques applicable to both single crystals and polycrystalline materials. (Prerequisite: MMS 304S)

U.M. Franklin, G.C. Weatherly

MMS405S PILOT PLANT OPERATIONS
IV-2B,8 - - - 4
This is a one-week laboratory experience conducted in the mineral processing pilot plant of the Ontario Research Foundation. Experience is gained in setting up and operating a pilot plant circuit for ore beneficiation. Principles of problem definition, planning, organization, operation, data collecting and reporting are emphasized.
R.T. McAndrew

MMS406S ADVANCED CHEMICAL METALLURGY
IV-5m,8; IV-2B (elective) 2 - 1 10
Selected topics related to the behaviour of metallic, ceramic, glass and metal-slag systems at high temperatures. Thermodynamic and transport properties of alloys and metallic oxides, carbides, silicides, etc. Corrosion reactions and vaporization processes. (Prerequisites: MMS 302F, MMS 401F)
S.N. Flengas, J.M. Toguri

MMS407S METALLURGICAL OPERATIONS ANALYSIS
IV-2B;IV-8 (elective) 2 - 2 10
The analysis of metallurgical operations in terms of process optimization and cost. Economic evaluation and venture analysis. Computer control of metallurgical processes and optimization through linear programming techniques. Application of numerical methods using FORTRAN and APL programming to charge calculations for furnaces, temperature distribution in furnaces, kinetics of metal refining processes. The lectures will be supplemented by seminars and field trips to local metallurgical industry.
C.B. Alcock, R.T. McAndrew

MMS408S MATERIALS ENGINEERING II
IV-8;IV-5m (elective) 3 - - 12
The course deals mainly with deformation processing and joining methods. The topics covered include: stress-strain relationships in unidirectional and combined stress states, deformation zone geometry, friction and lubrication, plastic flow instability, textures, structural changes during processing, forging,rolling, wire-drawing, extrusion joining methods such as welding, defects in processed materials, and fracture.
G.B. Craig and B. Ramaswami

MMS410F THEORY OF METALLURGICAL REACTIONS
IV-5m 2 - 2 12
Metal extraction and refining processes are examined in terms of chemical thermodynamics and kinetics. The principles and methods of extraction of ferrous and nonferrous metals, roasting, leaching and electro-winning are typical of the subjects discussed.(Prerequisite: MMS 306F)
J.M. Toguri

MMS411S ADVANCED MATERIALS SCIENCE
IV-5m; IV-8 (elective) 3 1.5 - 10
This course is offered to those students whose primary interest lies in the applied science aspects of materials. Recent developments in materials science are discussed in fields such as crystal growth, purification of materials, high-vacuum studies, preparation and characterization of clean surfaces, interfacial structures and properties, Auger emission and impurity segregation , environmental interactions. The laboratory work consists of research projects on contemporary problems in the field of materials science. (Prerequisite: MMS 402F)
K.T. Aust, J.W. Rutter

MMS412S MINERAL PROCESSING II

IV-2B;IV-8 (elective) 2 1.5 - 10

This is a continuation of course 301F. Topics considered include particle size analysis and characterization; the motion of solids in fluids under laminar, transitional and turbulent conditions, rheology and the application of surface chemistry to minerals, flocculation and flotation. (Prerequisite: MMS 301F)

H.U. Ross

MMS413F HYDROMETALLURGY

IV-6 (elective) 2 - 1 11

Theory and practice of metal production from ores and concentrates by chemical reaction in aqueous solution. Thermodynamic and kinetic fundamentals are emphasized. Topics covered include leaching, solution purification, metal precipitation, electrowinning and electrolytic refining. Examples of integrated process flowsheets are studied and compared to alternative pyrometallurgical processes.

R.T. McAndrew

MMS414F MINERAL PROCESS DESIGN

IV-2B;IV-8 (elective) 1 3 1 10

This course deals with the design, operation and control of mineral processing plants. Methods of estimating plant costs are studied. Groups of 4-6 students work together to design and cost a processing plant.

R.T. McAndrew

MMS416S NUCLEAR MATERIALS

IV-5m,5nt (elective) 2 - 1 10

An introduction to structure-property relationship in nuclear materials such as uranium, zirconium, stainless steel, etc. Topics to be discussed include properties of liquid metals and corrosion in liquid environments;creep thermal cycling and thermal fatigue; radiation damage; nonstoichiometry in inorganic compounds; production and fabrication techniques of fuel rods and canning and cladding materials. Production and fabrication of uranium, thorium, zirconium and other reactor materials. (prerequisite: any Materials Science course)

MMS417S APPLIED PHYSICAL METALLURGY

IV-5m,8 (elective) 3 - 1 10

This course deals with the application of scientific and engineering principles to materials selection and alloy design. The topics covered include: structure - property relationships in nuclear materials such as uranium, zirconium and stainless steel; methods of alloy design with special reference to applications for high and low temperature, radiation and corrosive environments; electronic, magnetic and composite materials; fracture mechanics and failure analysis.

Staff in Metallurgy and Materials Science

MMS420S ADVANCED IRON AND STEELMAKING

IV-2B,5m,8 (elective) 3 - - 10

This course deals with the application of the fundamentals of metallurgical chemistry to iron and steelmaking. Recent developments in solid state reduction processes, blast furnace practice, converter and arc-furnace steelmaking, deoxidation, inclusion control, gas injection, vacuum processes, ingot and continuous casting are discussed in the light of current publications.

A. McLean and H.U. Ross

MMS421S PHYSICAL CHEMISTRY OF IRON & STEELMAKING
IV-6 (elective) 2 - 1 11
Thermodynamics of molten iron alloys; gas-solid and slag-metal reactions in the blast furnace; alternative reduction processes; physical chemistry of steelmaking reactions; inclusion formation in steel; gas rinsing, vacuum processing, ingot and continuous casting.
H.U. Ross and A. McLean

MMS432F MATERIALS ENGINEERING I
IV-8;IV-5m (elective) 3 1.5 1 12
The course deals with the methods of materials processing such as powder metallurgy and solidification processing. The topics covered include: the production and agglomeration of powders, the theory and practice of sintering, the application of powder processing methods to the production of refractory metals, cemented carbides and other materials, solidification, the structure of castings, segregation, defects in castings, casting processes and applications of the principles of fluid flow and heat transfer to materials processing.
K.T. Aust, J.W. Rutter

MMS499Y THESIS
IV-8 - 6 - 9, - 12 - 18
The student chooses an experimental problem involving original work, which normally is related closely to the current research of a staff member. The student is asked to prepare a written report and two oral presentations describing the work.
Staff in Metallurgy and Materials Science

DEPARTMENT OF PHILOSOPHY

PHL291F SCIENCE AND SOCIETY

2 - - 12

A philosophical examination of the role of the scientist, technologist, and engineer in contemporary society, including some of the following problems: pollution and its control, war research, the "think tank", technocracy, nationalism.

PHL292S SCIENCE AND PHILOSOPHY

2 - - 12

The advance of the physical, social, and life sciences has produced successive changes in concepts familiar to the ordinary man (space and time; cause and effect; man and animal; purpose, motive, freedom). The philoscpher has attempted to work out the implications of these changes. This course will examine some of these attempts.

DEPARTMENT OF PHYSICS

PHY180F ELEMENTS OF PHYSICS I (MECHANICS)
I-5 2 1.5 1 12
A study of the foundations of classical mechanics, including frames of reference, linear and angular motion cf a particle, conservation cf energy, linear and angular momentum. Detailed discussion of the harmonic oscillator, the inverse-square law force, and introduction to rigid body dynamics, all with examples from modern physics. Labcratory emphasizes general principles of experimentation, while wcrking on selected and open-ended experiments. Text: A.P. French, Newtonian Mechanics
C.H. Chapman, B.P. Stoicheff

PHY181S ELEMENTS OF PHYSICS II (THERMODYNAMICS AND STATISTICAL PHYSICS)
I-5 2 1.5 1 12
Heat and thermodynamics, the laws of thermodynamics with physical applications. Ideal gases, kinetic theory, Maxwell-Boltzmann distribution of molecular velocities, specific heats of monatomic and polyatomic gases. Basic probability notions, postulates of statistical physics, entropy, absolute temperature, the canonical distribution. Text: Sears and Salinger, Thermodynamics, Kinetic theory and Statistical Thermodynamics
C.H. Chapman, C.O. Hines

PHY182S INTRODUCTION TO THERMAL PHYSICS AND WAVES
I-1,2,3,4,6,7,8 (elective) 3 1.5 - 12
An introductory course in Thermal Physics, Waves, Quanta, and Nuclei, intended to complement the Mechanics and Electricity offered to students in first year engineering. The course will range from classical thermodynamics, which is basic to many engineering processes through to selected topics in modern physics including nuclear energy. Lectures will be illustrated with demonstration experiments.

PHY280F ELEMENTS OF PHYSICS III (FIELDS AND WAVES)
II-5 3 1.5 1 12
Principle of relativity, Lorentz transformations, Einstein's special relativity, relativistic dynamics, space-time geometry, the electromagnetic field, analysis of a vector field. Electromagnetic field of uniformly moving charges. Electrostatic and magnetostatic fields. Maxwell's equations. Electromagnetic radiation and its generation. Synchrotron radiation. Interference of electromagnetic waves. Maxwell's equations in the presence cf matter.
A.E. Litherland

PHY281S ELEMENTS OF PHYSICS IV (QUANTUM PHYSICS)
II-5 3 1.5 - 12
Quantum concepts and the quantum aspect of electromagnetic radiation (photoelectric effect, Compton effect), wave particle duality (De Broglie hypothesis, wave packets, uncertainty principle), the Rutherford and Bohr atomic models;major emphasis on the mathematical understanding of the one dimensional Schroedinger equation; detailed solutions to a number of different potentials; the one dimensional harmonic oscillator; brief discussions of spectroscopy, nuclear, solid state, laser and high energy physics.
G. Luste

PHY282F/S INTRODUCTION TO MODERN PHYSICS

II-8; II-1 (elective) 3 - - 12

An introduction to the two major theories of twentieth century physics, relativistic mechanics and quantum mechanics, with examples of applications in atomic and nuclear physics. Reference: Tipler-Foundations of Modern Physics.

D.G. Ivey

PHY283F BASIC CLASSICAL AND MODERN PHYSICS

II-2 (elective) 3 - - 12

The analysis of physical systems using the basic laws of classical physics, i.e., mechanics and electromagnetism:- dynamics of rotation, multibody systems, description of fields, potential field theory, oscillating systems, wave propagation. This is followed by some topics in modern physics, particularly nuclear physics.

G.F. West

PHY324H GEOPHYSICS LABORATORY I

IV-2A,5g - 3 - 6, - 3 - 6

A laboratory course in geophysical prospecting methods, to accompany PHY338Y and PHY443Y. Assignments are designed to demonstrate how theory is applied to field situations. The program consists of weekly assignments that follow the lecture course. For students in PHY443Y, the program commences with a 10-day field camp held just before term begins. A fee of $45.00 per student will be charged to cover part of the cost of transportation and accommodation. During term the data taken in field camp may be interpreted as part of the sequence of assignments.

R.M. Farquhar, G.F. West

PHY326S MODERN PHYSICS LABORATORY

III-5p - 6 - 12

Experiments of both a pure and applied nature are available in the areas of atomic, molecular, solid state, nuclear and particle physics. The experiments are open-ended; the student may spend more or less time on any particular experiment depending on his particular interest. The course provides a framework for a student to learn significant areas of modern physics on his own initiative. The laboratory is open five days a week. Demonstrators will be in the laboratory at the times shown in the time-table and available for consultation at other times. Registration at the Physics office first week of term.

J. Prentice

PHY334F INTRODUCTION TO SOLID STATE PHYSICS

III-5m; III-5p, IV-5nt (elective) 2 - - 12

Introduction to the basic principles of solid state physics including; crystal structures and their determination using x-rays; propagation of waves in periodic structures; elastic waves, phonons, and thermal properties of solids; behaviour of electrons in crystalline solids and principal properties of metals, semi-conductors and insulators; selected features of superconductivity, magnetism and defects in solids. Text: R.A. Levy, Principles of Solid State Physics

E. Fawcett

PHY335F INTRODUCTION TO NUCLEAR PHYSICS
III-5nt;III-5p (elective) 2 - - 12
Important discoveries in nuclear and particle physics. Properties of the nucleus and of nuclei. The measurement of atomic masses; nuclear binding energies, binding energy and mass formulas, liquid drop and fission. Introduction to nuclear shell and collective models. Interaction of charged particles and uncharged particles with matter; particle detection, energy and momentum measurements. Radioactive decay phenomena: theory and experiment. Nuclear reactions and cross sections. Particle accelerators. (Prerequisite: PHY180F, 181S, 280F, 281S)

D.J. Rowe

PHY337S ELEMENTARY PARTICLE PHYSICS
III-5p (elective) 2 - - 12
This course presents a contemporary picture of the world of particle physics from a phenomenological rather than a theoretical point of view. The topics to be covered include the experimental method, types of interaction (weak, electromagnetic and strong), conservation laws and invariance principles, classification of particle states, and presently unsolved problems.

A.W. Key

PHY338Y EXPLORATION GEOPHYSICS
IV-2 2 - - 12, 2 - - 12
An introduction to the physical principles underlying the important methods of geophysical prospecting. Particular attention is given to seismic, gravitational, magnetic and electromagnetic methods. References: Dobrin, Introduction to Geophysical Prospecting; Parasnis, Applied Geophysics.

G.D. Garland

PHY344S ELASTICITY AND FLUID MECHANICS
III-5g 2 - - 12
A mathematical course in classical physics particularly for those interested in geophysics and meteorology. The elasticity part includes the definition and use of cartesian tensors to describe infinitesimal strains, stresses, and their relations. Fluid mechanics includes fluid statics, continuity, Bernoulli, Euler, and Navier-Stokes equations, potential flow, vortex flow. Textbook: R.R. Long - Mechanics of Solids and Fluids; D.R.F. Harleman - Fluid Dynamics.

PHY351S CLASSICAL MECHANICS
IV-5 (elective) 3 - - 12
Newtonian mechanics. Lagrange's equations and variational principles, the two-body problem. Hamilton's equations, canonical transformations. Poisson brackets, HamiltonJacobi theory, dynamics of rigid bodies, small oscillations. Reference: Goldstein, Classical Mechanics; Lanczos, The Variational Principles of Mechanics.

PHY359S RADIOBIOLOGY
III 5p,IV-5nt (elective) 2 - - 12
This course is intended for students in Physics and Engineering Science and assumes no prerequisite courses in biology at the university level. Topics to be covered include the physics of the interaction of radiation with matter, the effects of radiation on molecules and cells, applications of ionizing radiation in radiotherapy and nuclear medicine, and problems of radiation protection including genetics and health hazards. The emphasis will be on the use of quantitative techniques for measuring biological effects.

A.M. Rauth

PHY383F QUANTUM MECHANICS

III5nt,5p;III-5a (elective) 3 - - 12

This course builds on PHY 181S and PHY 281S, and will include: operator formalism and matrix methods, quantization of harmonic oscillator, one electron atom, and elementary perturbation theory.

PHY422F GEOPHYSICAL TIME SERIES ANALYSIS LABORATORY

IV-5g - 6 - 12

A laboratory concerned with mathematical and computational techniques for the analysis of discrete data series. Topics include Fourier, z and Laplace transforms in continuous and discrete representations, aliasing effects of sampling continuous functions, convolution and correlation, bandpass and optimum least squares, filtering and estimation of power spectra. The course is particularly relevant to geophysical data analysis. Reference: Kanasewich, Time Sequence Analysis in Geophysics.

R.C. Bailey

PHY423S INVERSION THEORY LABORATORY

IV-5g (elective) - 6 - 12

This is a continuation of PHY422F, but may be taken separately. Computational procedures for the interpretation and inversion of observations are investigated. (Prerequisite: PHY250Y, MAT235/239 or equivalent).

PHY424S GEOPHYSICS PROJECT LABORATORY

IV-5g - 6 - 12

For the 1978 session, students in 5g will participate in the setting up of an experiment to simulate atmospheric flow phenomena in a rotating system, using a specially designed laboratory model. This laboratory work will also serve to introduce students to the technique of non-dimensional analysis.

PHY425Y QUANTUM PHYSICS LABORATORY

IV-5p (elective) - 6 - 12, - 6 - 12

This laboratory is basically a continuation of PHY 326S. Experiments similar to those of PHY 326S are available but at a more advanced level. Some equipment of quality comparable to that used in contemporary research is available. Students have the opportunity to design and conduct experiments which have not previously been attempted in this laboratory. The laboratory is open five days a week. Demonstrators will be available in the lab at times shown in the timetable and available for consultation at other times.

PHY442Y PHYSICS OF THE EARTH

III-5g 2 - - 12, 2 - - 12

A course providing a physical background for the study of the interior of the earth, and the development of its surface features. Topics include seismic waves and the earth's structure, the gravitational field and the earth's mass distribution, geomagnetism, geochronology, and the mechanical and thermal properties of the earth's interior. Textbooks: Garland, Physics of the Earth; Mantle, Core and Crust; Stacey, Physics of the Earth. (Prerequisite: Open only to III, IV-5g)

PHY443Y THEORY AND APPLICATION OF GEOPHYSICAL METHODS

IV-5g 2 - - 12, 2 - - 12

The lectures stress the physical and mathematical theories of seismic, magnetic, electrical and gravitational methods. Considerable emphasis is placed on Fourier transform methods. Textbooks: Grant and West, Interpretation Theory in Applied Geophysics; Griffiths and King, Applied Geophysics.

N. Edwards

PHY444Y ATMOSPHERIC PHYSICS

IV-5g (elective 2 - - 12, 2 - - 12

A detailed survey of the earth's atmosphere. Topics include governing hydrodynamic equations, basic concepts of radiative transfer survey of atmospheric structure, hydrostatic stability and convection, some basic instabilities of the atmosphere, general circulation, numerical weather prediction, the upper atmosphere. References: Hess - Introduction to Theoretical Meteorology; Fleagle - Introduction to Atmospheric Physics.

T. Gal-Chen

PHY450Y QUANTUM THEORY

IV-5p (elective) 2 1 - 12, 2 1 - 12

Schrodinger equation, wave mechanics, Ehrenfest theorem. Hilbert space, operators, eigenvalue problems, representations, unitary transformations. The harmonic oscillator, second quantization, coherent states. Scattering theory, partial waves, Green's functions. Variational principle, perturbation theory, golden rules, emission and absorption of radiation. Angular momenta, spin, CG coefficients. Identical particles, Pauli principle, exchange. Klein-Gordon and Dirac equations. References: Powell and Craseman - Quantum Mechanics; Messiah - Quantum Mechanics I and II; Schiff - Quantum Mechanics.

PHY451Y STATISTICAL MECHANICS

IV-5p (elective) 2 1 - 12, 2 1 - 12

Microcanonical, canonical and grand canonical distributions. Microscopic discussion of entropy, temperature and chemical potential. Ideal classical and quantum gases. Approach to equilibrium and irreversibility. Applications to magnetic systems, specific heats, phase transitions and fluctuation phenomena. Texts: Landau & Lifschitz, Statistical Physics; Pathria, Statistical/Mechanics

PHY452Y RELATIVITY THEORY

IV-5p (elective) 2 1 - 12, 2 1 - 12

The course provides a unified description of relativity theory. An up-to-date presentation of the present experimental comparisons of different theories of gravitation is also given. Topics covered include: special theory: principle of relativity, Lorentz-transformations, Minkowski space, Maxwell's equations. General theory: principle of equivalence, general covariance, tensor algebra, Einstein's equations, Schwarzschild solution, geodesics, experimental tests of gravitation theory, gravitational collapse, black holes, gravitational radiation, cosmology. References: Schrodinger, Space-Time Structure; Weinberg, Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity; Misner, Thorne and Wheeler, Gravitation.

J. Moffat

PHY453Y NUCLEAR PHYSICS

IV-5nt,5p (elective) 2 1 - 12, 2 1 - 12

Nuclear forces and scattering. Neutron-proton scattering and pseudoscalar meson theory. Nuclear matter and mass formulae, properties of nuclei and their description in terms of shell and collective models, electromagnetic transistions in the nuclei, weak interactions, theory of nuclear reactions (a little) and the angular correlations of nuclear radiations. Texts: Paul, Nuclear and Particle Physics; Segre, Nuclei and Particles

T.E. Drake

PHY454Y HIGH ENERGY PHYSICS

IV-5p (elective) 2 1 - 12, 2 1 - 12

Introduction to concepts of high energy or particle physics. Topics include: particle accelerators and detectors, conservation laws and invariance principles in weak, electromagnetic and strong interactions, quark model and its application to strong and weak interactions.

R. Pugh

PHY455Y SOLID STATE PHYSICS

IV-5p (elective) 2 1 - 12, 2 1 - 12

Metals; free electron theory; periodic lattice; reciprocal lattice; energy bands and Fermi surfaces; transport theory. Lattice waves in solids; classical and quantum theories. Semiconductors; p-n junctions. Superconductivity and magnetic phenomena.

PHY456Y MODERN OPTICS AND RADIATION

IV-5p (elective) 2 1 - 12, 2 1 - 12

Propagation of electromagnetic radiation; relativistic optics; polarization; coherence and interference; interferometry; diffraction; holography; optics of solids; Fourier optics; atomic and molecular spectra; lasers and stimulated emission; nonlinear optics; multiphoton effects. Text: Fowles, Introduction to Modern Optics.

PHY457Y GROUP THEORY AND ITS PHYSICAL APPLICATIONS

IV-5p (elective) 2 1 - 12, 2 1 - 12

Elements of group theory; group representations; basis vectors, basis functions and quantum mechanics; point groups and space groups; crystal field splitting of atomic energy levels; symmetry properties and statistical weights of molecular rotational levels; molecular vibrations and normal modes; molecular orbitals; energy bands in solids; Landau theory of second order phase transitions. References: Boardman, O'Connor and Young, Symmetry and its Applications in Science; Tinkham, Group Theory and Quantum Mechanics.

PHY496S APPLIED PHYSICS LABORATORY

IV-5p - 6 - 12

A laboratory course whose purpose is to give students an opportunity to apply Physics to industrially relevant projects, in a way which stresses the design of the study, and the analysis of the results as well as the actual procedure. Students may select projects from a variety of areas (including Physics, Aerospace) with the guidance of a staff coordinator. Lists of possible projects will be available for consideration early in the Fall Term. Students will be required to present the results of their activities in a seminar and also in report form. The staff coordinator will monitor the progress of an assigned project and, if necessary, will see that a project is amended, or another substituted, if the general conditions of the course guidelines are not being met.

STATISTICS
(Department of Mathematics)

STA282S PROBABILITY AND STATISTICS
II-2, 8 2 - 2 12
Elements of probability theory. Binomial, Poisson and normal distributions. Sampling theory. Significance tests. Control charts. Least squares.

STA287S PROBABILITY AND STATISTICS
II-5 3 - .5 12
Definition of probability; binomial, Poisson, and normal distributions; frequency; sampling distributions. Examples of estimation, hypothesis testing, control charts, regression, and analysis of variance.

STA291F PROBABILITY
II-4 2 - 2 12
Elements of probability. Conditional probabilities and Bayes' formula. Continuous and discrete random variables. Expectation, variance, higher moments. Joint distribution of several variables. Independence, Chebyshev's inequality. Introduction to simple Markov chains. (Prerequisite: MAT186F, MAT187S)

STA292S STATISTICS
II-4 2 - 2 12
A continuation of STA291F. Random sampling. Law of large numbers. Estimation of parameters. Central limit theorem. Confidence intervals and tests of hypotheses. Regression. Introduction to experimental design and analysis of variance. (Prerequisite: STA291F)

STA347S PROBABILITY AND APPLICATIONS
IV-5 (elective) 3 - - 12
Probability theory (extending elementary results) especially conditional probability, random variables (multi-dimensional), characteristic functions, law of large numbers. Introduction to stochastic processes with a selection from the following topics: Markov chains (discrete or continuous time), renewal theory, covariance staticnary processes, turbulence and noise. (Exclusion: STA357)

ADDITICNAL COURSES

The courses listed below are not prescribed fcr any specific prcgram, but are included in this section to bring them to the attenticn cf interested students who may wish to choose one as an elective subject. The detailed course descriptions can be found in the appropriate calendar containing the listing cf the departments offering the courses.

APS401S	Social Impact of Technology	1 - 4 12
APS402F	Engineering Law	2 - 1 12
CED401Y	Project Design	- 2 3 12, - 2 3 12
CHE443Y	Organic Chemistry	2 3 - 12, 2 3 - 12
IND426S	Organizational Behavicur	- 5 - 12
STA347S	Probability and Applications	2 - 1 12